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ABSTRACT

This document is one in a series distributed by the Agricultural Extension Service of the University of Wyoming-Laramie. It presents the principles and methods of weed control especially as it relates to the use of herbicides. The factors influencing the effectiveness of both foliar-applied and soil-applied herbicides are discussed. A listing of the herbicides most commonly used for weed control is given with both trade and common names and the structural formula. (CS)

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WEED SCIENCE AND TECHNOLOGY

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TABLE OF CONTENTS

	Page No.
SECTION I - Principles and Methods of Weed Control	II - 1
A. Principles and Methods of Weed Control	II - 1
B. Control - Prevention - Eradication	II - 1
C. Life Cycles of Plants and Classification	II - 3
D. Methods of Control	II - 4
E. Types of Herbicides	II - 6
F. Herbicide Formulation	II - 9
SECTION II - Herbicide Selectivity	II - 11
A. Structural or Morphological Differences	II - 11
B. Absorption	II - 12
C. Translocation Differences	II - 13
D. Physiological Differences	II - 15
E. Types of Toxicity	II - 15
F. Concentration (Rate) of the Herbicide	II - 15
SECTION III - Factors Influencing Effectiveness of Foliar-Applied Herbicides	II - 16
A. Reaching the Plant	II - 16
B. Retention on the Leaf	II - 17
C. Loss	II - 17
D. Absorption Into the Foliage	II - 17
E. Translocation	II - 18
F. Deactivation	II - 18
G. Cellular Sensitivity	II - 19
SECTION IV - Factors Influencing Effectiveness of Soil-Applied Herbicides	II - 20
A. Factors Influencing the Effectiveness of a Herbicide	II - 20
B. Persistence in the Soil	II - 20
C. Microorganisms Decomposition	II - 21
D. Chemical Decomposition	II - 22
E. Adsorption on Soil Colloids	II - 22
F. Leaching	II - 23
G. Volatility	II - 23
H. Photodecomposition	II - 24
I. Soil Treatment - Herbicide Concentration	II - 24
SECTION V - Herbicide Mixtures and Problems in Mixing Herbicides	II - 26
SECTION VI - Herbicide Index	II - 28
SECTION VII - Herbicide List	II - 35
SECTION VIII - The Classification of Herbicides	II - 107
A. Inorganic Chemicals	II - 107
B. Organic Chemicals	II - 108
SECTION IX - Herbicide Chemistry Nomenclature	II - 118
SECTION X - Reference Material	II - 123

SECTION I

Principles and Methods of Weed Control

A. Principles and Methods of Weed Control

Recognition that a weed is a plant species growing where it is not desired, a plant out of place, or a plant that is more detrimental than beneficial, is a basic principle of weed control. Effective control of an individual species is dictated by the growth habits and methods of reproduction.

The Phenology, i.e. growth habits in relation to climate, is extremely important in determining the period of greatest susceptibility of a plant species to a control practice within a particular crop. Weeds which have growth characteristics similar to the associated crop are often more difficult to selectively control.

Stage of growth, soil type, climatic conditions, crop, and species of weeds are important factors which influence control practices. Consideration of the location of the weed infestation such as crop land, rangeland, orchards, wasteland, or industrial site further confounds the selection of proper control measures. Thus, it is important to recognize that weed control is complex, and that basic principles should be utilized for maximum effectiveness in combating weeds.

B. Control - Prevention - Eradication

1. Control is the process of containing and limiting weed infestations. The principle of control is to reduce the weed infestation, minimizing the competitive effect on a crop. Control is a method of decreasing the detrimental effects of weeds to crops while considering the cost of the operation. The competitive damage to crops caused by allowing a few weeds to escape may be economically justified when considering the cost of obtaining complete eradication. The principle of control usually pertains to annual weeds in farm crops.

   Six principle methods of control are:

   a. Mechanical

      1. hand pulling
      2. hoeing and spading
      3. tillage - disturbing root systems
      4. mowing
      5. flooding
      6. smothering

b. Cropping and competition

c. Biological control

d. Crop Rotation

e. Chemical

f. Fire

1. searing
2. flaming crops - cotton and corn

2. Prevention is forestalling the contamination of an area by a given plant species. This is the most practical method of controlling weeds. If no weeds are allowed to infest a field, there is no problem with control measures. However, the task of implementing an effective prevention program requires extreme caution and alertness.

Rules of preventive weed control are:

a. Use clean seed

b. Do not feed screenings, grain, or hay containing weed seeds without first destroying their viability by grinding, cooking or ensiling.

c. Do not use manure unless the viability of weed seeds has been destroyed by thorough fermentation.

d. Do not permit livestock from weed infested areas to move directly to clean areas.

e. Clean harvesters, cleaners, hay balers, disks, plows, and other implements before moving them from weed infested areas.

f. Avoid use of sand, gravel, and soil from infested areas.

g. Inspect nursery stock for presence of weed seeds, and tubers and rhizomes of perennial weeds.

h. Keep banks of irrigation ditches free from weeds.

i. Keep fence corners, fence lines, roadsides, and all other uncropped areas weed free.

j. Prevent the production of wind-borne weed seeds on any area.

3. Eradication is the complete elimination of all live plants, plant parts and seeds of the target species from an area. True eradication may be difficult since living plants and seeds (source for reinfestation) must be exterminated. Eradication is justified under conditions where small areas are infested with perennial weeds. Soil sterilization techniques can be used for complete elimination of green plants.

Weed seed contamination of the soil makes eradication nearly impossible in one season. Eradication programs should be designed to extend over several growing seasons to assure that all germinating seeds and seedlings have been killed. The development of selective herbicides in recent years has facilitated eradication of some perennial species without denuding the area of vegetation.

C. Life Cycles of Plants and Classification

In order to determine methods required to effectively control or eliminate an undesirable plant species, it is important to know the life cycle, i.e. length of time the plant lives, time of year it germinates and grows, and the type of reproductive capabilities the plant possesses. Plants are grouped according to three major types of life cycles: (1) annuals, (2) biennials, and (3) perennials.

1. Annuals are plants which complete their life cycle in less than one year. Annuals produce an abundance of seed since it is the sole source of survival. Thus, extremely dense infestations may occur on disturbed soil. A logical control program is the prevention of seed formation which breaks the life cycle. Most annual weed seeds will remain viable in the soil for one to seven years. Annual weeds are classified into two major categories: (1) summer annuals and (2) winter annuals.

   a. Summer annuals germinate in the spring, grow during the summer, produce seeds, and die in the fall. Seeds overwinter in the soil and germinate the next spring. Summer annuals include pigweeds, lambsquarter, nightshades, purslane, kochia, Russian thistle, marshelder, green foxtail, barnyardgrass, wild oats, and sandbur.

   b. Winter annuals germinate in the fall, grow and produce seed in the spring and early summer. The seed will lie in the soil during the summer months before germinating in fall. Winter annuals include tansy mustard, tumbling mustard, shepherd's purse, fanweed, and downy brome.

2. Biennials are plants which live for more than one year but not more than two years. Biennials reproduce from seed only; however, they overwinter by means of a taproot system. Usually, seeds germinate one season and produce a rosette with a fleshy taproot. The plant elongates and produces flowers and seeds during the second growing season. Winter annuals should not be confused with biennial plants.

3. Perennials are plants which live for more than two years. Some species are capable of living almost indefinitely. Usually perennials do not produce seed the year of establishment. Most perennials reproduce by seed and many are able to spread by vegetative means. Perennials are classified according to their vegetative reproduction capabilities: (1) simple perennials, (2) bulbous perennials, and (3) creeping perennials.

   a. Simple perennials are plants which reproduce almost solely by seed; however, they can produce new plants from cut pieces of

vegetative parts. Simple perennials have no special means (rhizomes or stolons) of reproduction. The roots of these plants are usually fleshy taproots that may become quite large. Dandelion, curly dock, buckhorn plantain, geyers larkspur, tall larkspur, and lupine are examples of simple perennials.

b. Bulbous perennials are plants which reproduce by bulbs, bulblets, and seed. Wild garlic produces aerial bulblets as the main means of reproduction, and also produces underground secondary bulbs. Death camas reproduces by seed, but established plants develop a deep bulb for nutrient storage and survival.

c. Creeping perennials are plants which spread by means of specialized modified above-ground stems (stolons) or below-ground stems (rhizomes), as well as by seed. Stolons and rhizomes produce vegetative buds which develop into independent plants. This group of plants is most difficult to control because of the diverse mechanisms for survival. In order to combat creeping perennial weed infestations, seed production must be stopped and vegetative propagation must be curtailed by killing both the above- and below-ground portions of the plant. Tillage implements will drag rhizome and stolon sections throughout a field making the containment of an infestation more difficult. Creeping perennials include Canada thistle, field bindweed, whitetop, perennial sowthistle, leafy spurge, white-leafed franseria, wild strawberry, ground ivy, quackgrass, Johnsongrass, and Bermudagrass.

4. Limiting vigor of perennials may be a means of control since all higher plants require sunlight, water, soil nutrients, and oxygen for survival. Limitation of any one of these factors will result in reducing a plant's vigor. If the life cycle of a perennial plant is disturbed by biological, mechanical, or chemical means, the vigor of the plant will be lowered.

Certain herbicides can be translocated from the foliage of the perennial plant to the root system where the action of the chemical kills the tissue, resulting in the restriction of water and nutrient uptake.

Climatic conditions can influence the vigor of plants. Areas with harsh winters may limit the plant's ability to survive. Mild winters may allow some biennial plants to act as short lived perennials (live more than two years). Dry conditions or alkali soils may limit a plant's vigor by inhibiting available soil moisture.

D. Methods of Control

As mentioned earlier, there are six principle methods of controlling weeds that are commonly utilized.

1. Mechanical control involves the use of tools to physically cut off, cover, or remove from the soil any plants that are undesired. Several methods are available.

a. Hand pulling is laborious and inefficient but an effective method of removing annual or biennial weeds. Most perennials are not effectively controlled by this method since they are capable of vegetative propagation from the root system.

b. Hoeing and spading are methods to cut off small annual and biennial weeds.

c. Tillage with mechanical implements can be utilized in two ways: first, it is effective on small annual weeds as a means of severing or covering the plants. When plants are larger, tillage effectiveness may be reduced. Second, tillage can be used to disturb perennial root systems. Cutting and disturbing the established roots can cause them to desiccate before they reestablish; however, multiple tillage operations are required to effectively control perennial weeds.

d. Mowing is a means of preventing seed production and reducing competition from weeds. Mowing is ineffective on low-growing plants. Multiple mowing of perennial weeds may serve to deplete the root reserves and result in the death of the plants. Removal of the top of plants by mowing can result in stimulating dormant buds which produce new stems.

e. Flooding is a physical means of removing the oxygen from the soil. Most annual and perennial weeds adapted to arid and semi-arid climates cannot tolerate this prolonged condition and die. Under most agricultural conditions, this method of control is not feasible.

f. Smothering can be accomplished by placing a barrier at the soil surface that plants cannot penetrate. If plants are unable to emerge into the sunlight, they will soon die for the lack of photosynthetic nutrition. This method of weed control is often utilized in high value crops and in flower gardens around the home.

2. Crop Competition as a method of weed control is based on the law of nature, "survival of the fittest." This is probably the cheapest and easiest method of controlling weeds. A crop will survive and flourish if it can compete more efficiently for sunlight, water, nutrients, and space than the unwanted plants. The growth habits of the crop in relation to the weeds are important factors in developing a crop competition system. Early weed competition is usually more detrimental to a crop than later competition when the crop is well established.

3. Biological Methods of control utilize natural predators of the undesirable plant species which are harmless to desirable species. Insects, diseases, parasitic plants, selective grazing, and competitive replacement plants are examples of biological control agents. Natural enemies which attack the plant species result in a "balance of nature" which is a control program rather than a means of eradicating a weed species. After the undesirable species (host plant) is removed, the predator agent population decreases as a result of the elimination of the food source. The weed species may increase again until the biological predator population recovers sufficiently to control the plants. This cycle may continue until a balance occurs.

Prickly pear cactus in Australia has been effectively controlled by a moth borer (Cactoblastis cactorum) which was introduced from Argentina. St. Johnswort is a severe problem in northern California and southern Oregon. The Klamath weed beetle (Chrysolina quadrigemina and C. hyperici) specifically feeds on the foliage of St. Johnswort. This has provided a natural means of curtailing the spread of a severe weed problem. The larvae of the painted-lady butterfly has effectively defoliated Canada thistle in Wyoming when the population has reached proper magnitude.

Climatic and environmental conditions are influential in the success of a biological predator for controlling weeds. The ability of the insect or organism to adapt to the environmental conditions of the host plant may be the most important factor in the success of the biological control program. Severe winters or prolonged drought may eliminate the predatory agent whereas the plant species can survive.

4. Crop Rotation can be a means of controlling weeds by providing a strong competitive crop on disturbed soil during all periods of a growing season. Weeds can flourish prior to crop establishment and after harvest. Early emerging crops can limit the growth of later germinating weeds. Farm managers should provide crop cover on cultivated areas during as much of the growing season as possible.

5. Fire is an effective tool for removal of vegetation from ditchbanks, road right-of-ways, and waste areas. Intense heat can sear green vegetation which usually dries sufficiently in 10 to 14 days that complete burning can be accomplished. Burning can kill small weed seeds on the soil surface and emerging weed seedlings. Selective flaming in corn and cotton is an effective method of controlling small annual weeds, but less effective on perennial species. Several treatments are required to control perennial species.

6. Chemicals are the most modern and efficient means for controlling unwanted plant species. Selective herbicides date back to the turn of the century, but the greatest advances have occurred in the last three decades. It is important to realize that herbicides are a product of modern technology and a tool for controlling weeds. Chemicals are not a replacement for good management practices and conscientious farming.

E. Types of Herbicides

1. Selective Herbicides are chemicals which can remove certain plant species with little or no damage to other species. Selectivity is usually obtained as a result of the way the herbicide is used. The selectivity of a chemical is not absolute and may depend on the following:

   a. The amount of chemical applied
   b. The way it is applied
   c. The degree of wetting the foliage
   d. The precipitation following treatment
   e. The inherent tolerance of a plant species to a specific herbicide
   f. Differences in growth habits of crops and weeds.

Since selectivity of a herbicide can depend on all of the above factors, a chemical may be utilized as a selective or nonselective treatment depending on intended use. 2,4-D can control grass seedlings although the primary use is the selective control of broadleaved weeds in grass crops. Atrizine at high rates is an effective soil sterilant even though its primary use is selective weed control in corn.

a. Foliage treatments are herbicide applications to the leaves of growing plants usually as sprays, mist, or dust.

1. Types of foliage treatments

a. Contact herbicides are chemicals that do not translocate or move in the plant. This group of herbicides kill only the plants or portions of the plant actually contacted by the chemical. In order to obtain effective control, adequate distribution or coverage of the foliage is essential. This can be accomplished by using high volumes of carrier or diluent to apply the herbicide. Some compounds which are classified as contacts are Dinitro, KOCN, DMA, diquat, paraquat, and selective weed oils.

b. Translocated herbicides are chemicals that move within a plant once the material is absorbed into the tissue. The greatest amount of transport is through the vascular system of the plant (phloem and xylem tissue). Translocated herbicides may be effective in destroying roots of perennial plants.

c. Selectivity depends primarily upon the morphological, physiological, and biochemical differences among plants. 2,4-D; 4(2,4-DB); 2,4,5-T; MCPA; picloram; dicamba; and dalapon are examples of translocated herbicides.

b. Soil treatments are herbicide applications to the soil. To be effective, the chemical must be carried into the soil by sprinkling or rainfall in order to be absorbed by the root system of the plant.

1. Classification of soil treatments

a. preplant - herbicide application prior to planting a a crop.

b. preemergence - herbicide applications after planting the crop but prior to crop or weed emergence.

c. postemergence - herbicide applications after crop or weed emergence.

2. Types of selectivity

a. Positional selectivity can be achieved by specific

location of the herbicide in the soil rather than tolerance of the desirable crop to the herbicide. Relatively insoluble compounds will remain near the soil surface and are absorbed by annual weed seedlings, but deep rooted crops are uneffected since the chemical does not readily leach. The crop could be extensively damaged if the herbicide was available for root uptake.

b. Crop tolerance is a means of selectivity where the herbicide is absorbed by the roots but the desirable plants have an inherent ability to destroy the herbicide by some biochemical process.

3. Stage of growth

a. Most soil applied herbicides are effective on germinating weed seedlings. Grass weed seedlings can absorb some herbicides through the coleoptile (protective sheath surrounding emerging seedling) or roots. Broadleaved weeds absorb the toxic material through the hypocotyl (lower stem) or root system.

2. Non-selective Herbicides are chemicals which are toxic to all plants. They may be used to remove a wide range of vegetation from an area. When no selectivity is intended, these compounds can be utilized to control vegetation along fence rows, around pipe lines, traffic signs, storage areas, and parking lots.

a. Foliage applications are treatments applied to vegetative portions of growing plants as sprays, mist, and sometimes dusts.

1. Contact sprays kill the vegetation covered. One treatment is usually sufficient to control annual weeds. Perennial plants require retreatment to control the vegetation. Acrolin, endothal, aromatic solvents, and sulphuric acid are examples of non-selective contact herbicides.

2. Translocated compounds move from the foliage to the roots, resulting in death of a wide variety of plant species. Relatively few herbicides can be classified into this group. Rates of application, time of application, and other factors can affect the selectivity or non-selectivity of many herbicides. Retreatment is usually necessary to maintain the plant vegetation. Glyphosate, ATA, and AMS are examples of translocated non-selective herbicides.

b. Soil Applications include a wide variety of soil fumigants and soil sterilants which are applied directly to the soil.

1. Soil fumigants are non-selective compounds which vaporize in the soil and kill all plant root systems and often kill seeds in the soil. They are relatively short-lived in the soil, and crops can be replanted within a month or less without toxic effects. Vapam and methyl bromide are examples of soil fumigants.

2. Soil sterilants are chemicals that kill all green plants for periods ranging from less than a month to many years.

Soil sterilants are classified as follows:

a. Non-residual treatments kill all green plant life and last for one or two days. Steam heat is the only non-residual sterilant. Temperatures of 212° F or greater for 30 minutes will kill weed seeds and plant roots.

b. Temporary sterilant kills all green plant life but lasts 4 months or less.

c. Semi-permanent treatment kills all green plant life but persists for 4 months to 2 years.

d. Permanent sterilant kills all green plant life for more than 2 years.

The length of time the soil remains sterile depends on the following:

1. Classification of the sterilant
2. Herbicide used
3. Application rate
4. Rainfall
5. Soil type and composition

F. Herbicide Formulation

Formulation may affect selectivity and activity of a herbicide. Application methods and equipment can vary greatly depending upon the type of herbicide formulation selected for a weed control practice. Herbicides may be formulated as follows:

1. Soluble salts are compounds which dissolve in water and require little or no agitation to stay in solution. Dalapon and 2,4-D amine are examples of soluble herbicides.

2. Emulsifiable formulations appear milky when mixed with water. The emulsifiable material breaks up into small droplets that are suspended in the water. Ester formulations are soluble in oil carriers. Since the emulsifiable formulations are insoluble in water, some agitation may be necessary which can usually be accomplished with the by-pass flow from the pump.

3. Wettable powders are finely ground, insoluble materials that are suspended in the water carrier. In order to maintain a uniform application rate, mechanical, or jet agitation in the spray tank must be provided. Slurries of the wettable powders and water mixed together prior to adding to the spray tank may eliminate the problem of getting the formulation into suspension.

4. Granules are formulated by adhering the herbicide to a dry material such as attaclay, corn cobs, boron, or sand particles. These formulations are applied to the soil surface since the dry particles do not adhere to the plant foliage.

5. Dusts are finely ground formulations of a herbicide that are blown onto the foliage of the plants. This method of application is nearly non-existent because of the extreme drift problem and the resulting hazard to susceptible crops.

SECTION II

Herbicide Selectivity

A selective herbicide is a chemical that is more toxic to one plant than to another. When such a herbicide is applied to a mixture of plants, some may be killed and others may be affected only slightly or not at all.

There are many factors which influence the selectivity and activity of herbicides. A knowledge of these factors is necessary to make proper herbicide selection and use. Selectivity is relative; it depends upon proper use of the specific herbicide.

The most important selectivity factors are (1) morphological or structural differences, (2) absorption, (3) translocation, and (4) physiological differences.

A. Structural or Morphological Differences

1. Structural Differences permit:

   a. selective application of herbicides

   b. protection of the plants meristematic region from herbicidal injury

   c. involvement of plant surface differences or orientation of plant parts which may affect spray retention and herbicide absorption.

2. Tall plants, with chemically tolerant stems, permit easy application of herbicides to weeds near the ground level.

   a. Chemicals are frequently applied to weeds and brush under tall trees without injury to them.

   b. Drop nozzles are utilized to spray weeds in sensitive crops such as cotton, corn, and sorghum. Selectivity is dependent upon placing the chemical near the ground line and only in contact to the stems of crop plants.

   c. Sprayers are also built with shields to protect the crop plants.

3. Location of the plants' growing points may be important.

   a. Broadleaved plants have exposed growing points at the tips of the shoots and in the axil of the leaves.

   b. In contrast, the growing points of cereals (monocotyledons) are located at the base of the plant and are protected by the

surrounding leaves. In some cases they are actually below the soil surface.

4. Grasses develop from lateral growing points which are usually protected.

   a. Grass stems elongate from the nodes, each node having meristematic tissue; the nodes are usually protected by a leaf sheath.

5. Perennial plants are often dormant during the winter months.

   a. At that time winter annuals can be controlled before the perennial crop emerges.

   b. Deep-rooted plants are often tolerant to chemicals which remain primarily in the soil surface. Shallow-rooted weeds may be killed. Annual weed control in dormant alfalfa is a good example.

6. Waxiness, hairiness, or pubescence of a plant may prevent spray droplets from adhering to the leaf.

   a. If the chemical droplets adhere, they may dry on wax scales or on the hair without coming in contact with the leaf epidermis, thereby preventing absorption.

   b. Hairiness may also increase herbicidal effectiveness - the hair may become saturated, increasing the quantity of the chemical spray held on the surface and reducing run-off.

B. Absorption

Absorption is the movement of a material into the plant from an external source (usually the leaves and roots).

1. To be effective, herbicides must enter the plant.

   a. Some plant surfaces absorb the herbicide quickly. Other plant surfaces absorb the chemical slowly, if at all.

   b. The chemical nature (oily, volatile, etc.) of the herbicide is also involved. Therefore, differential absorption or selective absorption may account for differences in plant responses.

2. Initial leaf penetration may take place through the leaf surface or through the stomates.

   a. The volatile fumes of some herbicides and some solutions enter through the stomates.

   b. Of far greater importance is the direct penetration of the leaf surface.

   c. On the leaf surface the herbicide must penetrate the cuticle layer and cell walls.

d. Polarity of the leaf surface and herbicide used is important. The waxy cuticle and cellulose of the plant leaves and stems are non-polar. Most organic substances are non-polar. Included in the non-polar group are oils and waxes, 2,4-D acid, 2,4-D esters, etc. Polar compounds include water, amino acids, salts of 2,4-D, etc. Non-polar compounds (2,4-D ester) tend to be absorbed into the leaves faster than the polar herbicides (amine of 2,4-D).

3. The addition of a wetting agent may reduce selectivity of the herbicide.

   a. A wetting agent tends to equalize foliar herbicide absorption in all types of plants.

   b. Wetting agents may reduce the selectivity of the herbicide if the selectivity is dependent upon selective foliar absorption.

4. Increase in temperature is usually associated with more rapid absorption.

   a. Within limits, the rate of such chemical processes tend to double with each increase of 17° F.

5. Roots absorb many herbicides from the soil.

   a. In general, roots are best adapted to absorbing polar substances, and absorb non-polar substances very slowly if at all.

   b. Upon contact with the soil, non-polar substances may be changed to polar substances.

   c. Tordon, Banvel and TBA are examples of root-absorbed compounds.

6. Rapidly-growing cells have a rapid rate of respiration.

   a. The factors that favor rapid growth of roots also favor rapid nutrient absorption.

   b. The rate of herbicide absorption from the soil is similarly affected.

C. Translocation Differences

1. Translocation of herbicides is a major problem in the control of weeds with below ground reproductive organs (deep-rooted perennials).

2. Translocation of herbicides within the plant involves the following:

   a. Translocation through the phloem (food conducting tissue).

   b. Translocation in the xylem (water and mineral conducting tissue).

   c. Translocation in space between the cells (intercellular).

   d. Movement of herbicides may take place from one of these systems to another system within the plant.

3. Translocation through the phloem

a. Translocation is usually in the general direction of moving from the leaves toward the roots.

b. Phloem tissues are composed of living cells. Extremely toxic chemicals kill the cells, stopping translocation. Excessive rates quickly immobilize or kill the phloem cells - stopping translocation.

c. Translocation is most rapid and most effective when large amounts of food reserves are being moved toward the roots. This usually occurs after full leaf development.

d. Calculations show that 2,4-D moves from the leaves to roots at rates up to 40 inches per hour.

e. Low rates of chemical, with repeated application, usually give better results, because plants are killed slowly.

f. Uniform application is more important than the amount of carrier used.

4. Translocation in the xylem

a. Herbicides move from the soil through the roots and upward along with the transpiration stream of water and soil nutrients.

b. A herbicide absorbed in a lateral leaf may be first translocated in the phloem to the xylem, then carried upward in the xylem.

c. Conductive tissue of the xylem is non-living, therefore, very toxic chemicals can be absorbed from the soil and translocated to all parts of the plant.

d. Absorption and translocation may continue even though the roots are killed.

e. Experiments indicate that the following three conditions must exist for translocation downward through the xylem to be effective. (1) a water deficit within the plant; (2) herbicide must render the tissues permeable between points of application and the xylem; and (3) plant must be exposed long enough to permit herbicide to penetrate.

5. Intercellular translocation

a. Non-polar substances may move through the plants' intercellular spaces.

b. Oils may be absorbed by the plant through the cuticle, epidermis, bark, stomata and even injured roots.

c. Oils move in any direction -- up, down, or radial.

d. It is generally believed that the oil moves principally through intercellular spaces. The 2,4-D esters in kerosene act similarly.

D. Physiological Differences

1. Scientists only partially understand the physiological differences which account for selective herbicidal toxicity.

2. Differences in enzyme systems, response to pH changes, cell metabolism, cell permeability, variation in chemical constituents, and polarity may be involved.

3. A change in one or more of these may either stimulate or block certain biochemical processes.

4. Enzyme reaction may be blocked in one plant species but not in another.

5. Activation of an inactive chemical into an active compound (2,4-DB) being an example.

6. Decomposition of a herbicide into a harmless compound. One of the best examples is the ability of corn to decompose simazine.

7. The basic fundamentals of photosynthesis and respiration are important in understanding how herbicide affects plants. Entire textbooks are available and are too lengthy to include in this outline.

E. Types of Toxicity

1. Two types of toxicity to plant tissue, acute and chronic have been shown through research.

a. Acute means "intense" or "penetrating"; thus rapid killing of the plant. Contact herbicides usually produce acute toxicity.

b. Chronic means of "long duration" or continuing for a long time. Chronic toxicity may show little visible effect for a week or longer. Growth regulators usually produce chronic toxicity.

F. Concentration (Rate) of the Herbicide

1. The rate of application may determine whether the herbicide inhibits or stimulates the plants.

2. Under many conditions, 2,4-D may speed up the rate of respiration and cell division, but in excessive rates may immediately slow down the rate.

3. The concentration of the herbicide at a vital location in the plant at any one given time may determine the herbicide effectiveness.

4. Crop yields generally increase where herbicides have effectively controlled weeds. While there is a possibility of herbicide stimulation, the increase in yield is probably a result of less competition.

SECTION III

Factors Influencing Effectiveness of Foliar-Applied Herbicides

The application of a herbicide to the leaves of weeds is a direct way of getting the chemical into the plant and eventually to the "site of action." It is common knowledge that populations of the same species of plants receiving the same herbicide, under similar conditions do not react similarly. If this is the case, there must be something influencing the uptake and movement of the herbicide reaction of the plant to the herbicide, or other factors of application which may influence the effectiveness.

For a foliage-applied herbicide to be effective it must successfully follow the chain of events listed below.

1) reach the plant
2) be retained on the leaf
3) penetrate the leaf
4) move to the site of action
5) remain toxic long enough to exert its action.

A. Reaching the Plant

This factor is many times overlooked in practical field situations.

1. There are at least three ways the proper amount of herbicide fails to reach the leaves ----

   a. Spray drift is the movement of the spray particles including the carrier from the target area.

      1. Spray drift is more common with air application and where smaller droplets are produced.

      2. Large nozzles and lower pressures will reduce the potential of drift.

   b. Volatilization is the change of a herbicide from the solid or liquid state into a gaseous form.

      1. Several herbicides are of such a volatile nature that significant losses of the herbicide can occur.

      2. It is important to recognize the difference between spray drift and volatility and select non-volatile compounds where movement of the gaseous phase may cause crop damage.

c. "Canopy" effect - or in common terms, shading by taller plants.

1. Often an overlying canopy can intercept, not only contact herbicides, but also translocated herbicides, and the herbicide fails to reach or contact smaller plants underneath the canopy resulting in poor control.

B. Retention On The Leaf

Once the herbicide comes in contact with the leaf, it must be retained on the surface long enough to be absorbed. Several factors can be involved in retention.

1. Morphology of the plant -- where the leaves are upright or horizontal-- may determine whether the spray remains on the leaf or runs off.

2. Whether the leaf is waxy or non-waxy. (Garlic leaf vs. mustard leaf)

3. Characteristics of the spray solution - these can be altered by the addition of additives or "adjuvants". Wetting agents can often act as sticking agents when used in low volumes of water.

4. Volatility may be important - some herbicides may evaporate too rapidly for adequate retention time.

5. Sprays composed of small droplets and applied at high pressure and low volumes increase retention.

C. Loss

The herbicide may be deposited on the leaf surfaces only to be removed by rainfall. Salts of various herbicides may be lost after the spray solution evaporates, leaving free crystals on the surface. High temperatures lead to loss of volatile materials. Exposure to light may result in chemical breakdown before absorption can occur.

D. Absorption Into The Foliage

The absorption or uptake of a herbicide is influenced by many factors. Herbicides can enter the leaves either through the lower or upper surfaces. Usually the lower surfaces are more permeable than the upper surface. The herbicide can penetrate the leaf through the stomates or directly through the cuticle. The relative importance of the two routes of penetration is open for debate and differences of opinion are common. The absorption depends upon species involved and the environmental conditions (light, humidity, whether the stomates are open or closed). The formulation of the herbicide is also important.

Four important things can happen after the herbicide is retained on the leaf.

1. It can remain on the surface as a crystal or a liquid. This happens to many salt formulations when the water carrier evaporates.

2. It can enter the cuticle and remain dissolved in the non-polar portion. This can happen with weed oils.

3. It can enter and move in the aqueous phase along cell walls to the vascular system. Amitrole and dalapon are examples.

4. It can enter and move directly into living cells and through them to the vascular system. 2,4-D is a good example.

The absorption of herbicides is a very important concept relating to the activity of foliar applied herbicides. The distances the herbicide must move in getting into the leaf are very small. However, the composition and character of the leaf surface may be a very significant barrier to the entry of herbicides. This one factor can contribute to failures when herbicide activity is dependent upon absorption and translocation.

E. Translocation

Foliage applied herbicides can either be of the contact-type which kill only the tissues with which they come in contact or the systemic herbicides which must move from the point of application to other parts of the plant. The systemic herbicides include such compounds as 2,4-D, amitrole, and dalapon.

An important concept in relation to translocation deals with the symplast and apoplast.

1. The symplast refers to the total interconnected protoplasm of all plant cells functioning as a unit. This includes phleom, living cells, the plasmodesmata (strands of protoplasm connecting living cells), etc.

2. The apoplast consists of non-living tissues and water surrounding the symplast. This includes the xylem and secondary walls. Herbicides can move short distances by simple diffusion, but for the true systemic action they must move in either the xylem or phloem. Certain herbicides move entirely in one or the other, where some can move in those of the tissues.

3. The "source to sink" concept is a concept very important in understanding translocation.

   a. The sink refers to a site within the plant at which sugars are being used either to form storage materials or in active metabolism. Sugars tend to move from the areas of the leaf where they are manufactured (source) toward the sink, and in the process can carry 2,4-D and other compounds along. Since most translocation of herbicides from the leaves occurs in the phloem, which is living tissue, rapid burning of the leaves and stems can be detrimental to translocation. Toxic herbicides or high rates of application simply kill the tops of plants with little movement to the roots.

F. Deactivation

A herbicide may be readily absorbed and as soon as it reaches the living protoplasm of a plant it is subject to decomposition, or it may be incorporated in the cells. In either case, the concentration of active herbicide in the plant tissue is reduced.

G. Cellular Sensitivity

The final response of a plant to a herbicide is at the cellular level. Different tissues of the plant vary widely in sensitivity to a herbicide. Newly developing cells are usually affected by low concentrations; mature plants develop tolerances.

SECTION IV

Factors Influencing Effectiveness of Soil Applied Herbicides

A herbicide may be applied to the soil for the purpose of killing, selectively in agriculture or unselectively on industrial sites. Despite the variability in performance of soil applied herbicides they are used on a large scale. Therefore, it is very important that factors contributing to performances be fully understood.

A. Factors Influencing the Effectiveness of a Herbicide

1. Herbicides applied to the soil are directly affected by soil characteristics. Those applied to the foliage are less affected by soil differences.

2. The numerous soil factors, the many different kinds of herbicides, the large number of plant species, and climatic variations make the study of herbicides in soils very complex.

3. Herbicides are applied directly to the soil as:

   a. Preplant treatments
   b. Preemergence treatments
   c. Postemergence treatments
   d. Soil sterilants

4. Some chemicals are applied to the surface while others require incorporation.

5. Since most annual weeds germinate in the upper 1/2 inch of soil, the success of preemergence treatments depends upon the presence of high concentrations of the herbicide in this zone.

6. If germinating seeds in the soil surface are killed, the surface may remain weed-free for a period of time after the chemical has disappeared. Many weed seeds will not germinate if buried deeply in the soil.

7. For effective sterilization the herbicide must remain active in the rooting zone to kill both germinating seeds and deep-rooted plants.

B. Persistence in the Soil

The length of time that a herbicide remains active or persists in the soil is extremely important as it relates to the length of time weed control may be expected. Residual toxicity is also of paramount importance as it

relates to phytotoxic after-effects that may prove injurious to succeeding crops or plantings.

1. Herbicides may disappear faster with large amounts of water that provide heavy leaching and with repeated cultivation or mixing of the soil.

2. In some cases fertilizers can be added to reduce injurious after-effects.

3. The use of charcoal in reducing phytotoxicity is becoming a popular practice.

4. Seven factors affecting the persistence of herbicides in the soil are:

   a. Microorganism decomposition
   b. Chemical decomposition
   c. Adsorption on the soil colloids
   d. Leaching
   e. Volatility
   f. Photo-decomposition
   g. Loss by cropping

C. Microorganism Decomposition

The principal microorganisms in the soil are algae, fungi, and bacteria which must have food for energy and growth. Organic compounds of the soil provide this food supply, except for a very small group of organisms that feed on inorganic sources. Some chemicals are readily decomposed (utilized by microorganisms), whereas others resist decomposition.

1. Microorganisms immediately attack organic substances applied to the soil and can increase in numbers. This hastens decomposition. Microorganisms can be quite specific for certain herbicides. It is also possible that the increase in microorganism activity from an initial application of a herbicide will result in more rapid breakdown of subsequent applications and require higher rates of application to obtain similar results. Organisms may also die when the food supply is gone.

2. Other factors besides the food supply may quickly affect the growth and multiplication of microorganisms. These are temperature, water, oxygen, and nutrient supply.

   a. Most soil organisms are nearly dormant at 40° F, with 75 to 90° F being most favorable.

   b. Most organisms go dormant or die without water and are very sensitive to an adequate supply of oxygen.

   c. Deficiency of nutrients, such as nitrogen, phosphorous or potash may reduce growth.

3. Thus, warm, moist, well-aerated, and fertile soil is most favorable to microorganisms and under ideal conditions can most quickly decompose organic herbicides.

4. Herbicides may remain toxic for extended periods of time if the soil is cold, dry, poorly aerated, or other conditions are unfavorable to the microorganisms.

5. The usual rate of herbicide application is not expected to change the organism population to a great extent.

   a. The herbicide may benefit one group of organisms and injure other groups.

   b. When the herbicide is decomposed, the microorganism returns to "normal".

   c. Herbicides vary in their persistence. Most chemicals used on cultivated crops disappear in less than 6 months; some such as atrazine persist longer.

D. Chemical Decomposition

Very unstable compounds are obviously of little value for killing plants by soil application and root uptake. They could not survive while the slow means of transfer available carried them to their site of action through the very reactive moist soil. Incorporation (mechanically mixing into the soil) of such unstable compounds helps to off-set this property. Compounds that are resistant to chemical decay for longer than one cropping season can create problems to subsequent sensitive crops and therefore may be of little value in selective weed control.

1. Chemical decomposition destroys some herbicides and activates others. Examples of chemical decomposition include:

   a. Dalapon which will slowly hydralize in the presence of moisture, rendering it ineffective as a herbicide

   b. Sesone which is decomposed to 2,4-D.

E. Adsorption on Soil Colloids

The primary effect of adsorption of herbicide on the soil particles is to reduce, sometimes to a very small fraction of the whole, the concentration of herbicide freely available in the soil water.

1. Observations in research work have shown the following:

   a. Soils high in organic matter require large amounts of preemergence and soil sterilant herbicides for weed control.

   b. Soils high in clay content require more herbicide than sandy soils for preemergence or soil sterilant weed control.

   c. Soils high in organic matter and clay content tend to hold the

herbicide for a longer time than sandy soils and the adsorbed herbicide may be released so slowly that the chemical is not effective as a herbicide.

d. A certain amount of herbicide is required to saturate the adsorptive capacity of the soil. Above this "threshold level" heavier rates will greatly increase the amount of chemical in the soil solution, and thus increase herbicidal toxicity to plants.

F. Leaching

Leaching is the downward movement of a substance in solution through the soil.

1. The movement of a herbicide by leaching may determine its effectiveness as a herbicide, may explain selectivity, or may account for its removal from the soil.

2. Most preemergence herbicides are applied to the soil surface and are dependent upon rainfall to leach them into the upper soil surface or germinating weed seed zone.

3. Weed seeds germinating in the chemical impregnated zone are killed. Large seeded crops planted below the area of high herbicidal concentration escape injury.

4. The extent to which a herbicide is leached is determined principally by:

   a. Solubility of the herbicide in water

   b. Amount of water passing through the soil

   c. Adsorptive relationships between the herbicide and the soil.

5. In general herbicides which are completely water soluble are most easily leached. But some water soluble herbicides may react with various parts of the soil and form a molecule which is relatively stable.

G. Volatility

Loss of evaporation is probably more significant than is generally realized for many surface-applied herbicides. In a temperate summer, if the soil surface could remain moist, water would be lost at a rate of about 200 tons/acre/month from the soil only.

1. All chemicals, both liquids, and solids, have a vapor pressure.

   a. The evaporation of water is an example of a liquid, and the vaporization of naphthalene (moth balls) is an example of a solid that will vaporize.

   b. At a given pressure, vaporization of both liquids and solids increases as temperatures rise.

2. Herbicides may evaporate and be lost to the atmosphere as volatile gases. This can result in poor weed control and/or damage to susceptible crops.

3. The herbicide may move into a porous soil as a volatile gas.

   a. EPTC (eptam) is thought to move as a volatile gas. Adsorbed by the soil, EPTC may effectively kill certain germinating weed seeds.

4. Rain or irrigation water applied to a dry or moderately dry soil will usually leach the herbicide into the soil, or aid in its adsorption by the soil.

   a. Once adsorbed by the soil, loss by volatility is usually reduced.

   b. Where rainfall or immediate irrigation is not common, incorporation assists in reducing losses.

H. Photodecomposition

Photodecomposition, or decomposition by light, is reported for some herbicides. Chemicals applied to the surface are frequently lost, especially if they remain for an extended period without rain. There is always the possibility of herbicide loss caused by photodecomposition. However, do not overlook other factors which may account for the loss.

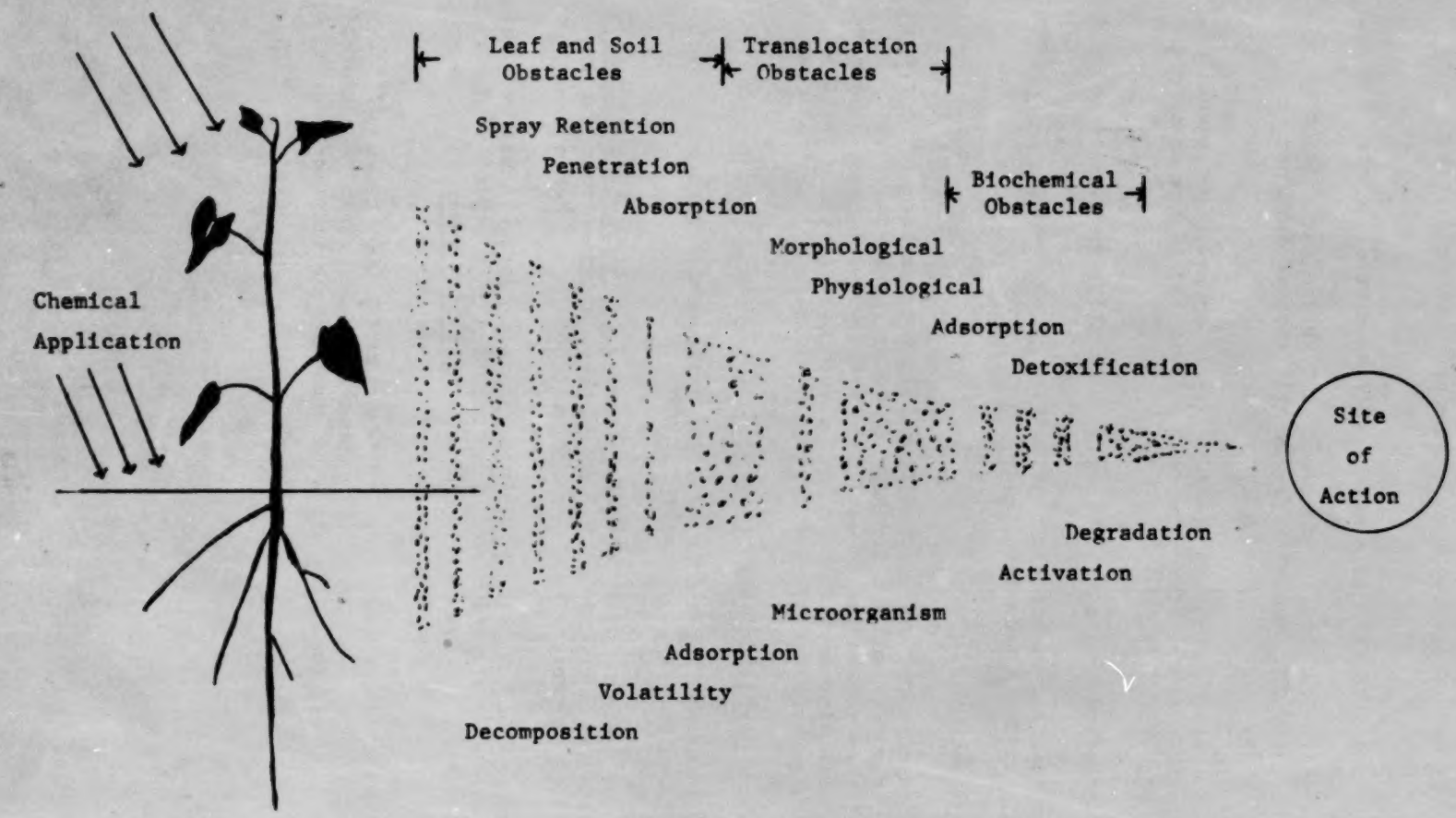
I. Soil Treatment - Herbicide Concentration

Any herbicide applied to the soil for action is confronted by two important factors.

1. First - soil weighs, on an average, about 3.5 million lb/acre foot, 300,000 lb/acre inch. Thus, 3.5 lb of chemical mixed into the top foot of soil is present at a concentration of 1 part per million (ppm).

2. Secondly - the water holding capacity of soils varies. Most herbicides act through the soil solution. Concentration of a given dosage in the soil solution will thus depend not only on fixing power but also on amount of water in the soil.

   a. Soil moisture per acre foot varies from 300,000 to 1.5 million pounds. Thus a water soluble chemical would attain a concentration (in solution) five times as great in the first as in the second soil.



Obstacles Which Determine the Concentration of Toxic Material at the Site of Action

Section V

Herbicide Mixtures and Problems in Mixing Herbicides

The use of herbicide combinations is not new, but it has not received the attention and input that is necessary to fully understand and implement the practice.

Although the number of herbicides available is continually increasing, we have to realize that in most cases herbicides are quite specific in their activity toward either grass or broadleaf weeds and even other species within these broad categories. Excellent herbicides have limitations that might be alleviated with the proper addition of another herbicide.

There are several advantages that may be gained from the combination of herbicides over a single chemical. Some of these are:

1) Control of a broader spectrum of weeds.
2) More consistent control over a wide range of climatic conditions.
3) Reduced potential of herbicide residue in crops and soils.
4) Lower rates of application resulting in decreased crop injury and lower costs.
5) Unexpected synergistic effects (increased herbicidal effectiveness beyond that expected.)

There have been limitations and concern in the past concerning the legal use of herbicide combinations. At no time have we recommended mixtures unless the herbicides, herbicide-fertilizer mixtures, and other pesticides were registered and had been thoroughly researched.

The recent Environmental Protection Agency policy concerning tank mixes and serial applications is not greatly different than what we had previously outlined as guidelines; however, the EPA policy in its entirety is being included for your information as dated May 24, 1973, and is as follows:

Subject: Tank Mixes and Serial Applications-
Interpretation of the Amended FIFRA

From: Deputy Assistant Administrator
Office of Pesticide Programs

"There have been many questions raised with respect to tank mixes (combinations of two or more pesticides in the spray tank at time of application) or serial application of one pesticide immediately or shortly following the application of another, as the practices relate to use

consistent with the label. This memorandum states OPP policy with respect to such practices and is consistent with EPA statement of Janaury 9, 1973, which provided for informal interpretation of use inconsistent with label instructions as such questions arise."

Tank mixes and serial applications may fall into one of several categories:

Cateogry 1. Instructions provided for such use on one or more labels of EPA registered products;
Category 2. Such use may be covered by an intra-state registration;
Category 3. Various tank mixes and serial applications have been tested and recommended by Agricultural Experiment Stations, State Departments of Agriculture or are common agricultural practices.

Tank mixes or serial applications recommended on EPA labels (Category 1) are obviously consistent with the label and do not constitute use inconsistent with such label.

Intra-state registrations remain valid until replaced by EPA registrations under Section 3 of the amended FIFRA. This will occur generally after October 21, 1974 and be completed by October 1976, under the schedule spelled out in the law; or by special actions taken by the Administration in the form of orders bringing products under sole EPA registration at some earlier time. This latter action will occur primarily with respect to products containing the same active ingredients and registered intra-state for the same kinds of users as the Administrator has cancelled or suspended in inter-state commerce under the 1974 version of the FIFRA. The first and only action of this nature taken to date was the April 10, 1973 order with respect to registration of products containing DDT.

Therefore, tank mixes and serial applications registered by a State (Category 2) will not be deemed uses inconsistent with the label.

Finally, the legislative history of the amended FIFRA shows that the Congress intended EPA to apply the test of reasonability in enforcing misuse provisions. From this point of view, during a transitional period while parties adjust to the new law, tank mixes and serial application in Category 3 will not be deemed use inconsistent with the label if:

a) The products in the mix are applied at a dosage rate not to exceed the label instructions for use of any product in the mix used singly for the same set of insects on the same crop; and
b) The label on one or more of the products does not explicitly instruct against such mixture.

It must be recognized under Categories 2 and 3, that EPA has not reviewed any efficacy or human and environmental safety data on the combination of products and the user applies them in this manner at his own risk in respect to effects on crops and application equipment, applicator safety,

environmental effects and tolerance pre-harvest intervals. The policy of deeming such use not inconsistent with the label, may not be construed as EPA approval of the use.

If adverse effects are observed from a particular tank mix or serial application, EPA may take appropriate action to rule the use of such specific mix or serial application to be inconsistent with label instructions on a case-by-case basis. Regional offices are requested to be watchful of any adverse effects and advise OPP of such through the Pass system, calling special attention to the casual nature of the event.

This policy will be in effect until modified by further statements or regulations. It has been reviewed by General Council and is legally acceptable under the amended FIFRA and meets with the acceptance of the Office of Enforcement.

The key words in the entire interpretation made by the EPA are use consistent with the label and uses deemed not to be inconsistent with the label.

The policy of deeming such use not inconsistent with the label, must not be construed as EPA approval of the use and the user applies them at his own risk.

A number of compounds are registered and are being used and recommended as tank mixes or as packaged combinations. Some that are included in the Wyoming Weed Control Guide as tank mixes are: Treflan + Eptam, Banvel + 2,4-D, and Lasso + AAtrex. Prepacked, or mixed combinations include Knoxweed (Eptam + 2,4-D), Pre Beta II (Ro-Neet + Avadex) and Pyramin plus (Pyramin + Dalapon).

Even though we now have guidelines with respect to tank mixes and serial applications there still remains the question of compatability when mixing two or more compounds especially when directions for mixing and applying are not included on the label.

Both chemical and physical incompatability are a possibility. With chemical incompatability the chemical may be completely deactivated, the spray solution might be made highly phytotoxic, resulting in serious injury to crops or foliage, or change the mammalian toxicity whereby a normally safe spray could be highly dangerous. Physical incompatability is most commonly evidenced by precipitation in the spray solution which takes the form of crystalline solids, foundation of a gelatinous mass, or separation of components which takes the form of layering.

Chemical compatability of a combination is impossible to determine without extensive research being conducted. However, the physical compatability can be checked and should always be checked before mixing large quantities. The compatability can be checked by using the "fruit jar" method or some other method where the combinations can be determined.

Wettable powder herbicides should be pre-slurried before addition to a spray tank. Adding the wettable powder directly to the spray tank can result in "globs" or unwetted material in the tank. This is particularly a problem with the more finely ground wettable powders.

Tank mixtures of a wettable powder and an emulsifiable concentrate can cause problems if not done properly. The proper procedure is to first pre-slurry the wettable powder and add it to the tank 3/4 full of water. The emulsifiable concentrate should be then added followed by the necessary water to fill the tank. If the sequence is reversed with the wettable powder added last, problems can arise.

If a compatability agent is necessary to improve mixing or to prevent formation of undesirable and unsprayable gels or precipitates, while agitating add it to the carrier already in the tank. Follow the directions for use of the compatability agent.

The compatability of any two or more herbicides put together as a mix can be predetermined by mixing small proportional quantities in advance.

Fertilizer and Herbicide Mixtures

The mixing of liquid fertilizers and pesticides and applying at the same time has several advantages. The "energy crisis" with the scarcity of fuel may increase the adoption of this practice. The mixing of the two materials could save time, labor and fuel and may help reduce soil compaction.

There could be mixtures of a herbicide + fertilizer = "weed + feed"; fertilizer + insecticide = "feed and worm"; herbicide + insecticide = "weed and worm"; and herbicide + fertilizer + insecticide = "weed, feed and worm". The following discussion will be concerned only with the "weed and feed" concept of mixing herbicides with liquid fertilizer solutions.

Even before checking the compatability of herbicide + fertilizer mixtures, other factors of importance must be taken into consideration.

Do you have the right equipment for application?

1. Fertilizer application is not as exacting as for applying herbicides. Uniform application covering every square inch is essential for the effectiveness of herbicides. The equipment ordinarily used for applying fertilizers does not give the uniform distribution pattern that equipment used for herbicide application provides.

2. Some fertilizer application equipment does not have the agitation necessary to keep herbicides uniformly dispersed.

3. Herbicide application equipment may not be able to withstand the weight and corrosiveness of liquid fertilizers nor apply the necessary volume of liquid fertilizer.

Are mixtures of herbicides and fertilizer practical?

The applicator must determine if the timing of application, placement and distribution of each component in the mixture are similar enough to be applied as a mixture.

Timing - Several herbicides and fertilizers can be applied at the same time. For example, AAtrex (atrazine) can be tank mixed with liquid fertilizer and applied to corn either preplant incorporated or broadcast on the soil surface after the corn is planted but before the crop emerges. Placement of the mixture may raise a question of practicality. Suppose a farm operator sprays the herbicide and fertilizer mix over the corn row, in a band, at planting time. By using a nitrogen solution as a carrier for the herbicide the nitrate form of nitrogen will be incorporated by rainfall. If the ammonium (NH_4) form of nitrogen is used as a carrier and soil surface applied, it will react with the soil particles and be held in the top 1/4 inch of soil. This nitrogen will move downward only after being converted to the nitrate form. If the fertilizer carrier for the herbicide is a solution containing nitrogen and phosphorus it will have to be positioned in the soil near the roots for plants to adequately utilize it as phosphorus does not move readily in most soils. If the nitrogen and phosphorus fertilizer solution is banded over the corn at planting time, the corn will not benefit from the phosphorus as a starter in early plant growth. Thus, this combination would not be practical from a placement standpoint.

Distribution of the mixture.

Liquid fertilizers are usually broadcast over the entire field. Applying the herbicide in with the fertilizer means broadcasting of the herbicide also. Many herbicides can be band applied, a practice which reduces the total cost of the herbicide/acre in proportion to the row-spacing and width of band treated. Therefore the total benefits and economics of mixing should be taken into consideration.

Is the fertilizer-herbicide compatable?

Herbicides may not always mix evenly throughout liquid fertilizer or the components may separate making their use impractical. A simple test can and should be used before mixing large quantities. A standard compatability test follows:

A. Materials Needed

1. Two 1-quart jars marked with an identifiable letter, number or other means. Usually "with" and "without" is the most practical.

2. Teaspoons (for more accurate testing, a ml pipette or graduated cylinder).

3. A minimum of 1 quart of the liquid fertilizer to be used as a carrier.

4. The herbicide(s) to be used.

5. The compatability agent (such as compex or Spanto 168-D)* (the adjuvant helps keep the fertilizer and herbicide in suspension). Other compatability agents are available.

B. Procedure

1. Add 1 pint of the liquid fertilizer or other herbicide carrier that will be used to each jar marked "with" and "without".

2. Add to the jar marked "with", 1/4 teaspoon or 1.2 ml of a suitable compatability agent; shake gently for 5 to 10 seconds (1/4 teaspoon is the equivalent of 2 pints/100 gallons of liquid fertilizer).

3. To each jar, add the appropriate herbicide(s). Shake gently for 5 to 10 seconds.

Product	Rate/A		Material to be added per pint of liquid fertilizer (assuming volume is 25 gal/A) Teaspoons		Milliliters
Wettable Powders	1.0	=	1.4	or	7
	2.0	=	2.9	or	14
	4.0	=	5.8	or	28
Emulsifiable concentrates, flowables, liquid, or solution	1 pint	=	0.5	or	2.4
	1 quart	=	0.9	or	4.7
	2 quarts	=	1.9	or	9.5
	1 gallon	=	3.8	or	19.0

This compatability test is designed for 25 gallons of spray/acre of the herbicide as indicated. For different spray volumes or herbicide rates make the appropriate changes of the ingredients of the test. Regardless of spray volume, the compatability agent should be added at the rate of 2 to 3 pints/100 gallons of liquid fertilizer.

*Compex, manufactured by Colloidal Products Corp., and Spanto 168-D by Retzloff Chemical Co.

C. Observations and Decisions

1. If the herbicide(s) and the liquid fertilizer are compatable, and;

2. If the compatability agent is needed.

Five minutes after the final addition and mixing, observe both jars for the formation of large flakes, sludge, gels or other precipitates. Check to see if the herbicide(s) cannot be physically mixed with the liquid fertilizer but remains as small oily droplets in the solution.

If incompatability occurs in the jar "without" the adjuvant but not in the jar "with" the adjuvant, the use of a compatability adjuvant is recommended.

If incompatability in any form occurs in the jar "with" the compatability agent added, the liquid fertilizer and the herbicide should not be used together in the same spray tank.

Both jars should be allowed to stand and be observed periodically for 1/2 hr. If the separate layers of liquid fertilizer and additives can be resuspended by shaking commercial application is possible. An emulsifiable concentrate normally will go to the top after standing; wettable powders will either settle to the bottom of the tank or jar, or float on the top, depending upon the density of the fertilizers.

The compatability of herbicides with a water carrier can be checked by utilizing the same "fruit jar" method outlined for fertilizer herbicide mixes.

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The section on herbicide-fertilizer mixtures was extracted in part from: (1) Fertilizer and Herbicide Mixtures. Proc. 1974 Crop Protection Clinics. University of Nebraska and Herbicide Handbook 1974, Monsanto Company, Agricultural Division.

SECTION VI

Herbicide Index

Herbicide	Page No.
AAtrex	II - 36
acrolein	II - 43
Agroxone 3	II - 70
alachlor	II - 67
Amchem Amitrole-T	II - 39
amiben	II - 37
Amino triazole	II - 38
amitrole	II - 38
Amitrole-T	II - 39
Ammate	II - 40
Ammate X	II - 40
AMS	II - 40
Anchor Brand Carbon Bisulfide	II - 52
Ansar 159	II - 74
Ansar 170	II - 74
Ansar 184	II - 60
Ansar 529 H.C.	II - 74
Ansar 8100	II - 60
Ansar DSMA Liquid	II - 60
Aqualin Herbicide	II - 43
ATA	II - 38
Atlacide	II - 91
atrazine	II - 36
ATZ	II - 36
Avadex	II - 41
Avadex BW	II - 42
Balan	II - 44
Banvel	II - 45
barban	II - 53

Herbicide Index (continued)

Herbicide	Page No.
Baron	II - 46
benefin	II - 44
bensulide	II - 48
Benzac 1281	II - 105
benzadox	II - 98
Betanal	II - 47
Betasan	II - 48
Bladex	II - 49
Borascu	II - 50
Borax	II - 50
bromacil	II - 64
Brominal	II - 51
bromoxynil	II - 51
Buctril	II - 51
Butoxone SB	II - 103
Butoxone Ester	II - 203
butylate	II - 93
cacodylic acid	II - 79
Carbon disulfide	II - 52
Carbyne	II - 53
Casoron	II - 54
CDAA	II - 86
CDEC	KK - 106
Chem-Hoe	KK - 65
Chloramben	II - 37
chlorbromuron	II - 69
chloropropham	II - 55
CIPC	II - 55
Concentrated Borascu	II - 50
cyanazine	II - 49
cycloate	II - 87
cyprazine	II - 75
Cytrol Amitrole T	II - 39

Herbicide Index (continued)

Herbicide	Page No.
Dacthal	II - 56
dalapon	II - 59
DCPA	II - 56
Des-i-cate	II - 61
diallate	II - 41
dicamba	II - 45
dichlobenil	II - 54
dinoseb	II - 58
diquat	II - 57
diuron	II - 66
DMA-4	II - 102
DNBP	II - 58
DSMA	II - 60
Dow General	II - 58
Dow Selective	II - 58
Dowfume	II - 71
Dowpon	II - 59
endothall	II - 61
Endothal-TCA	II - 61
Eptam	II - 62
EPTC	II - 62
erbon	II - 46
Erbon R	II - 46
Far-Go	II - 42
fenac	II - 63
Fen-All	II - 105
Garden Weeder	II - 37
General Chemical Chlorate	II - 91
Hydrothal Plus	II - 61
Hyvar	II - 64
Hyvar-X	II - 64

Herbicide Index (continued)

Herbicide	Page No.
Hyvar X-L	II - 64
Hyvar X-P	II - 64
IPC	II - 65
karbutilate	II - 94
Karmex	II - 66
Karmex DL	II - 66
Knoxweed 42	II - 62
Kuron	II - 89
Lasso	II - 67
linuron	II - 68
Lorox	II - 68
Malaeic hydrazide	II - 72
Maloran	II - 69
MC-2	II - 71
MCPA	II - 70
Methyl Bromide	II - 71
Methoxone	II - 70
Metobromuron	II - 76
MH	II - 72
MH-30	II - 72
MH-30T	II - 72
Milogard	II - 73
monuron	II - 96
MSMA	II - 74
nitralin	II - 80
Ornamental Weeder	II - 37
Ortho Diquat	II - 57
Outfox	II - 75

Herbicide Index (continued)

Herbicide	Page No.
paraquat	II - 77
Patoran	II - 76
PCP	II - 78
PEBC	II - 97
pebulate	II - 97
Pentachlorophenol	II - 78
Pestmaster	II - 71
phenmedipham	II - 47
Phytar 138	II - 79
Phytar 560	II - 79
picloram	II - 99
Planavin	II - 80
Polybor	II - 81
Pramitol	II - 82
Prefar	II - 48
Premerge	II - 58
princep	II - 83
prometone	II - 82
propachlor	II - 85
propazine	II - 73
propham	II - 65
Pyramin 80W	II - 84
pyrazon	II - 84
Ramrod	II - 85
Randox	II - 86
Reglone	II - 57
Retard	II - 72
Ro-Neet	II - 87
sesone	II - 88
siduron	II - 101
silvex	II - 89
Silvisar 510	II - 79

Herbicide Index (continued)

Herbicide	Page No.
simazine	II - 83
Sinbar	II - 90
Sinox General	II - 58
Sinox PE	II - 58
Sinox W	II - 58
Sodium Chlorate	II - 91
Sodium TCA Inhibited	II - 95
Soil Fumigant-1	II - 71
Sprout-stop	II - 72
Sucker-stuff	II - 72
Sumitol	II - 92
Sutan	II - 93
Tandex	II - 94
TCA	II - 95
Telvar	II - 96
terbacil	II - 90
Tillam	II - 97
Topcide	II - 98
Tordon	II - 99
Tordon-212 mixture	II - 99
Tordon Beads	II - 99
Tordon 10K Pellets	II - 99
Tordon 22K	II - 99
Trans-Vert	II - 74
Treflan	II - 100
triallate	II - 42
trifluralin	II - 100
Trysben 200	II - 105
Tumbleaf	II - 91
Tupersan	II - 101
2,3,6 TBA	II - 105
2,4,5-TP	II - 89
2,4-D	II - 102

Herbicide Index (continued)

Herbicide	Page No.
2,4-DB	II - 103
2,4,5-T	II - 104
United Chemical Defoliant No. 1	II - 91
Vegedex	II - 106
Weedar 64	II - 102
Weedar MCPA Concentrate	II - 70
Weedazole	II - 38
Weedone 638	II - 102
Weedone MCPA Ester	II - 70

SECTION VII

Herbicide List

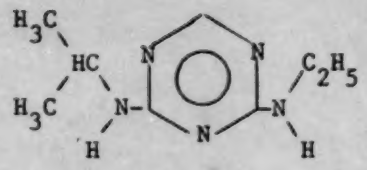
The herbicides listed are those most commonly used for weed control in Wyoming. This is not a complete list of all herbicides or combinations of herbicides available. Both trade names and common names are listed. The acute LD_{50} (lethal dose to 50% of the test animals) has been stated along with the estimated dose to cause death of a 150-pound man and is only an approximation based on the LD_{50} of the test animal (in most cases rats). The intent of the estimated dose figure to man is only tc present a more easily understood toxicity comparison. This is an acute or immediate poisoning rating and does not show what the chronic or long-range effect might be.

AATREX

Common Name: atrazine

Chemical Name: 2-chloro-4-(ethylamino)-6-(isopropyl-amino)-s-triazine

Structural Formula:



Formulation: 80% wettable powder and 4 lb/gal. water dispersible liquid.

Manufacturer: Geigy Chemical Corp.

Acute Toxicity: LD_{50} - 3,800 mg/kg

Precautions:

1. Flammability: Nonflammable
2. Corrosiveness: Noncorrosive under normal use
3. Very low toxicity to game and fish species

Herbicidal Use: Widely used selective herbicide for control of broadleaf and grassy weeds in corn, sorghum, sugarcane, macadamia, orchards, pineapple, etc. Also used for selective control in conifer reforestation, Christmas tree plantations and grass seed fields, as well as non-selective control of vegetation in chemical fallow. AAtrex is also used as a non-selective herbicide for vegetation control in non-crop land.

Remarks: AAtrex will persist under Wyoming conditions to effect some rotational crops one year following treatment at normal rates of application.

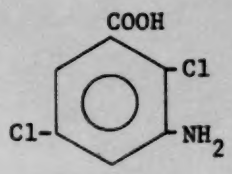
AMIBEN

Common Name: chloramben

Other Trade Names: Garden Weeder, Ornamental Weeder

Chemical Name: 3-amino-2,5-dichlorobenzoic acid

Structural Formula:



Formulation: 2 lb/gal. soluble concentrate and 10.8% granules

Manufacturer: Amchem Products, Inc.

Acute Toxicity: LD_{50} - 3,500 mg/kg

Precautions:

1. Flammability: Nonflammable
2. Corrosiveness: Noncorrosive
3. Not toxic to fish and wildlife when used as directed

Herbicidal Use: Preemergence control of seedling grass and broadleaf weeds in dry beans, corn and various ornamentals.

Remarks: Moisture needed to activate. Emerged weeds are not controlled.

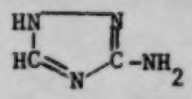
AMITROLE

Common Name: amitrole

Other Trade Names: Amino triazole, Amitrole, Weedazol, ATA, ATZ

Chemical Name: 3-amino-s-triazole

Structural Formula:



Formulation: 90% soluble powder

Manufactuers: Amchem Products, Inc.
American Cyanamid Co.

Acute Toxicity: LD_{50} - 24,600 mg/kg

Precautions:

1. Flammability: Aqueous, nonflammable
2. Corrosiveness: Mildly corrosive to iron, aluminum, copper and copper alloys
3. Not toxic to wildlife or fish when used as recommended

Herbicidal Uses:

1. Perennial broadleaf weeds and grasses in non-cropped areas.
2. Foliar-applied translocated non-selective herbicide

Remarks: Causes characteristic chlorosis in plants. Has short soil residual life. Use for non-cropped areas only.

AMITROLE-T

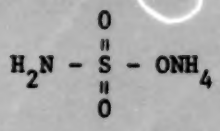
Other Trade Names:	Cytrol Amitrole T, Amchem Amitrole-T
Chemical Name:	3-amino-s-triazole plus ammonium thiocyanate (2 lb/gal of each)
Formulation:	2 lb/gal. soluble concentrate and 1% aerosol
Manufacturers:	Amchem Products, Inc. American Cyanamid Co.
Acute Toxicity:	LD_{50} - 5,000 mg/kg
Precautions:	Same as amitrole
Herbicidal Uses:	Same as for amitrole. Lower rates of Amitrole-T give results equal to higher rates of amitrole. Foliar applied translocated non-selective herbicide.
Remarks:	Same as amitrole. Amitrole-T is more effective on some species of weeds and at lower rates than amitrole.

AMS

Other Trade Names: Ammate X, Ammate

Chemical Name: ammonium sulfamate

Structural Formula:



Formulation: 95% soluble crystals

Manufacturer: E. I. DuPont de Nemours & Co.

Acute Toxicity: LD_{50} - 3,900 mg/kg

Precautions:

1. Flammability: AMS has fire retardant properties.
2. Corrosiveness: Equipment should be washed thoroughly after use to reduce corrosion.
3. Avoid prolonged contact of skin with strong solutions.

Herbicidal Use: Effective in killing most woody plants, including hardwood and coniferous species. Also effective as a contact spray for control of herbaceous perennials such as leafy spurge, bitter dock, goldenrod, perennial ragweed, milkweed, as well as most annual broadleaf weeds and grasses.

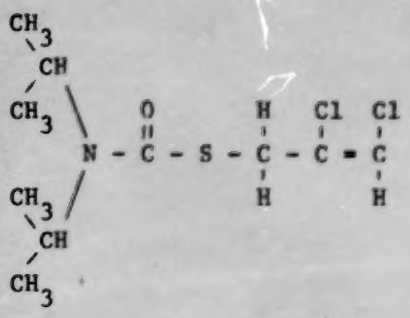
Remarks: Safe to use where 2,4-D is a hazard. Used to kill tree stumps around homes.

AVADEX

Common Name: diallate

Chemical Name: S-(2,3-dichloroallyl) diisopropylthiocarbamate

Structural Formula:



Formulation: 4 lb/gal. emulsifiable concentrate and 10% granules

Manufacturer: Monsanto Co.

Acute Toxicity: LD_{50} - 395 mg/kg

Precautions:

1. Flammability: Nonflammable
2. Corrosiveness: Noncorrosive

Herbicidal Use: Control of wild oats and certain other grasses and broadleaf weeds in sugarbeets. Also for wild oat control in flax, barley, forage legumes, potatoes, etc.

Remarks: Incorporate immediately after application. Needs moisture for activation. Main region of chemical uptake of grasses is through the coleoptile.

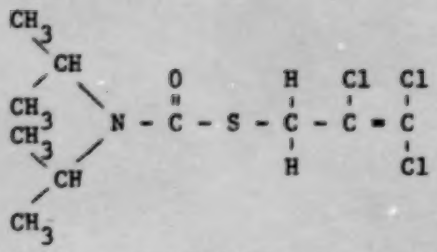
AVADEX BW

Other Trade Name: Far-Go

Common Name: triallate

Chemical Name: S-(2,3,3-trichloroallyl)diisopropylthiocarbamate

Structural Formula:



Formulation: 4 lb/gal. emulsifiable concentrate

Manufacturer: Monsanto Co.

Acute Toxicity: LD_{50} - 1,675 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. May be irritating to eyes and skin.

Herbicidal Use: For control of wild oats in peas, barley, durum and spring wheat.

Remarks: Pre- and postplant, soil incorporated. Less volatile than diallate (Avadex).

AQUALIN HERBICIDE

Common Name: acrolein

Chemical Name: acrylaldehyde (2-propenal)

Structural Formula: $CH_2 = CH - CHO$

Formulation: 92% liquid

Manufacturer: Shell Chemical Co.

Acute Toxicity: 46 mg/kg

Precaution:

1. Do not contaminate with any foreign material at any time. To avoid the possibility of polymerization keep under oxygen-free nitrogen only.

2. Corrosiveness: Iron and low carbon steel are unaffected at room temperature. Can be stored under oxygen-free nitrogen in dark glass bottles, in cylinders, or in black iron drums.

3. Data show that fish vary considerably in their tolerance to acrolein. Fish kill can be avoided by treating half the area, allowing fish to migrate to untreated area.

Herbicidal Use: For control of submersed weeds (Potamogeton, Najas, Zannichellia, Ceratophyllum, Spirogyra, and others) and floating weeds (water cress, water hyacinth and water primrose) in irrigation canals, ditches, drains and ponds. Not phytotoxic to common field crops when used as directed by product label.

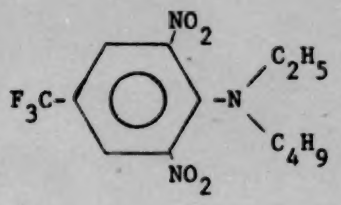
Remarks: Vapor flammable. Use only under the supervision of licensed operators.

BALAN

Common Name: benefin

Chemical Name: N-butyl-N-ethyl-α,α,α-trifluro-2,6-dinitro-p-toluidine

Structural Formula:



Formulation: 1.5 lb/gal. emulsifiable concentrate

Manufacturer: Elanco Products Co.

Acute Toxicity: LD_{50} - 10,000 mg/kg

Precautions:

1. Flammability: Use ordinary precautions for volatile solvents.
2. Corrosiveness: Noncorrosive.
3. No hazard to mammals and birds; toxicity to fish under study; properties preclude possibility of hazard to fish.

Herbicidal Use: Annual broadleaf and grassy weed control in alfalfa, red clover and established turf grasses.

Remarks: Requires soil incorporation simultaneously with or immediately after application to prevent loss of activity.

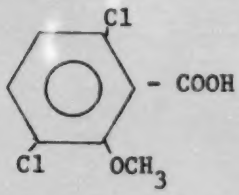
Residual at higher rates of application may be a problem on crops following.

BANVEL

Common Name: dicamba

Chemical Name: 3,6-dichloro-o-anisic acid

Structural Formula:



Formulation: 4 lb/gal. soluble concentrate, 4, 5, and 10% granules

Manufacturer: Velsicol Chemical Co.

Acute Toxicity: LD_{50} - 1,040 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Low order of corrosion.
3. Low order of toxicity to fish and wildlife.
4. Prevent spray drift to susceptible broadleaf crops.

Herbicidal Use: Foliar and soil applied control of phenoxy-tolerant annual and perennial broadleaf and brush species. Registered uses in small grains, corn, flax, perennial seed grasses, turf, and non-crop lands.

Remarks: Produces effects similar to 2,4-D and other auxin type herbicides. Shows promise of effectively controlling perennial weeds in combination with cultivation under Wyoming conditions.

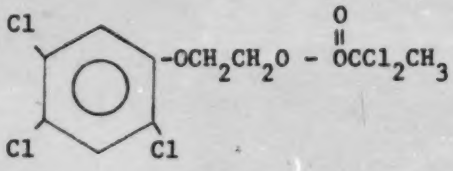
BARON

Common Name: erbon

Other Trade Names: Erbon R

Chemical Name: 2-(2,4,5-trichlorophenoxy)ethyl 2,2-dichloropropionate

Structural Formula:



Formulation: 4 lb/gal.

Manufacturer: The Dow Chemical Co.

Acute Toxicity: LD_{50} - 1,120 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Corrosive to spray equipment.
3. No hazard to wildlife when used according to label instructions.

Herbicidal Use: A non-selective herbicide for general vegetation control in non-crop areas.

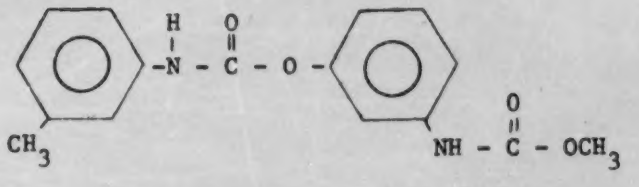
Remarks: Use enough material to cover thoroughly all vegetation and exposed soil. Major effect on perennial broadleaf weeds results from root uptake.

BETANAL

Common Name: phenmedipham

Chemical Name: methyl m-hydroxycarbanilate m-methyl-carbanilate

Structural Formula:



Formulation: 1.3 lb/gal. emulsifiable concentrate

Manufacturer: Noram Agricultural Products, Inc.

Acute Toxicity: LD_{50} - 8,000 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. Lethal concentration of 0.02 ml of phenmedipham per liter of water to trout.
4. Do not breathe spray mist.

Herbicidal Use: Postemergence sugar beet herbicide

Remarks: Do not use more than 30 gpa of spray solution per acre on a broadcast basis. The compound is temperature sensitive. Low temperature- low activity, high temperature - increased activity and phytotoxicity.

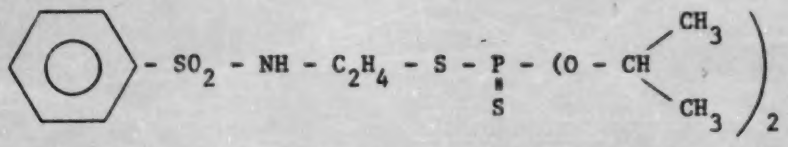
BETASAN

Common Name: bensulide

Other Trade Names: Prefar

Chemical Name: O,O-diisopropyl phosphorodithioate S-ester with N-(2-mercaptoethyl)benzene-sufonamide

Structural Formula:



Formulation: 4 lb/gal. emulsifiable concentrate

Manufacturer: Stauffer Chemical Co.

Acute Toxicity: LD_{50} - 1,910 mg/kg

Precautions:

1. Flammability: Flash point 300° F.
2. Corrosiveness: Corrosive to copper.
3. the 96 hr LD_{50} in rainbow trout is 0.72 ppm.

Herbicidal Use: Registered for control of crabgrass, annual bluegrass and other annual broadleaf and grassy weeds in grass and dichondra lawns.

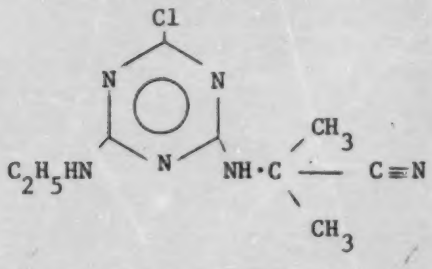
Remarks: Must be applied to soil before germination of weed seeds. Apply prior to planting, at time of planting, or on established dichondra lawns.

BLADEX

Common Name: cyanazine

Chemical Name: 2-([4-chloro-6-(ethylamino)-s-triazine-2-yl] amino]-2-methylpropionitrile

Structural Formula:



Formulation: 80% wettable powder, 4 lb/gal. water dispersible liquid

Manufacturer: Shell Chemical Co.

Acute Toxicity: LD_{50} - 334 mg/kg

Precautions:

1. Flammability: Nonflammable
2. Corrosiveness: Noncorrosive
3. Low order of toxicity to wildlife and fish

Herbicidal Use: Preemergence weed control on corn.

Remarks: Under prolonged, dry soil conditions the herbicide should be incorporated into top two inches of soil.

BORASCU

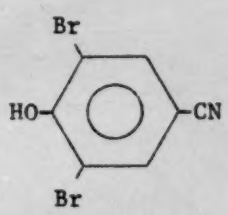
Common Name:	borax
Other Trade Names:	Concentrated Borascu
Chemical Names:	Anhydrous sodium tetraborate, Pyrobor anhydrous sodium tetraborate, Sodium metaborate, V-bor sodium tetraborate, Pentahydrate, and Tronabor agricultural sodium borate.
Structural Formula:	
	$Na_2 B_4 O_7$ (anhydrous)
	$Na_2 B_4 O_7 \cdot 5H_2O$ (pentahydrate)
	$Na_2 B_4 O_7 \cdot 10H_2O$ (decahydrate)
Formulation:	91 to 95% granular crystals, frequently mixed with other compounds.
Manufacturer:	United States Borax and Chemical Corp. American Potash and Chemical Corp.
Acute Toxicity:	LD_{50} - 2,500 mg/kg
Precaution:	1. Flammability: Nonflammable
	2. Corrosiveness: No corrosion hazard to ferrous metals.
	3. General toxicity to wildlife and fish low.
Herbicidal Use:	Non-selective vegetation control, adapted to preventing emergence under asphalt.
Remarks:	Persistence dependent upon rate, soil type and rainfall. Excellent fire retardants and are frequently combined with sodium chlorate, urea herbicides etc.

BROMOXYNIL

Other Trade Names: Buctril, Brominal

Chemical Name: 3,5-dibromo-4-hydroxybenzonitril (4-cyano-2,6-dibromophenol)

Structural Formula:



Formulation: 2 lb/gal. emulsifiable concentrate

Manufacturers: Amchem Products, Inc.
Rhodia, Inc., Chipman Division

Acute Toxicity: LD_{50} - 250 mg/kg

Precautions:

1. Flammability: Salts nonflammable. Ester formulation flash above 82° C.
2. Corrosiveness: Noncorrosive to spray equipment.
3. May be toxic to fish and wildlife.

Herbicidal Use: Selective postemergence contact herbicide registered for use on wheat, barley, and newly seeded turf.

Remarks: Controls some weeds resistant to 2,4-D. Can be applied to seedling grain and grasses without toxicity associated with 2,4-D.

CARBON DISULFIDE

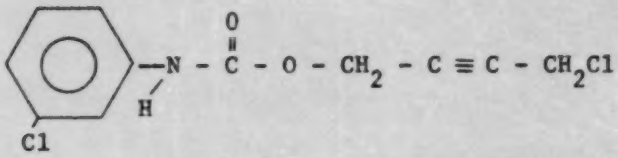
Other Trade Name:	Anchor Brand Carbon Bisulfide
Chemical Name:	Carbon disulfide
Structural Formula:	CS_2
Formulation:	95% active liquid
Manufacturers:	Pittsburgh Plate Glass Co. Stauffer Chemical Co. and others
Acute Toxicity:	Vapor: 1,200 to 4,000 ppm, toxic by inhalation of vapor, prolonged or repeated contact of the liquid with the skin, or oral intake.
Precautions:	Static electricity may ignite the fumes during draining from a barrel. Barrel should be grounded.
Herbicidal Use:	Non-selective soil applied temporary soil sterilant.
Remarks:	Vapor is poisonous and explosive. Used for perennial weed control.

CARBYNE

Common Name: barban

Chemical Name: 4-chloro-2-butynyl m-chlorocarbanilate (4-chloro-2-butynyl N-(3 chlorophenyl)carbamate)

Structural Formula:



Formulation: 1 lb/gal. emulsifiable concentrate

Manufacturer: Gulf Oil Corp.

Acute Toxicity: LD_{50} - 1,350 mg/kg

Precautions:

1. Flammability: 178° F
2. Corrosiveness: Liquid concentrate may cause corrosion of tin plate and mild steel at the liquid-air interface. Aluminum, phenolic lined cans or glass are recommended for lengthy storage.

Herbicidal Use: Wild oat control in spring wheat, durum wheat, barley, flax, peas, sugarbeets, safflower, lentils, mustard, and soybeans.

Remarks: Carbyne is a skin irritant and sensitizer to some people.

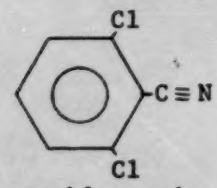
Timeliness of application for effective wild oat control very important.

CASORON

Common Name: dichlobenil

Chemical Name: 2,6-dichlorobenzonitrile

Structural Formula:



Formulation: 50% wettable powder, 4% and 10% granules

Manufacturer: Thompson-Hayward Chemical Co.

Acute Toxicity: LD_{50} - 2,710 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Essentially noncorrosive.
3. No adverse effects to fish or wildlife.

Herbicidal Use: Casoron is a powerful inhibitor of germination. Both broadleaf and grassy weeds are controlled. Has wide use in established hedges, flower gardens, etc.

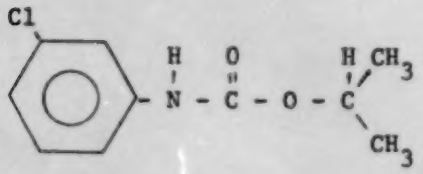
Remarks: Has several uses for around the home - perennial flower gardens, hedgerows, etc. Apply to weed-free surface.

CIPC

Common Name: chloropropham

Chemical Name: isopropyl m-chlorocarbanilate

Structural Formula:



Formulation: 4 lb/gal. emulsifiable concentrate and 20% granules

Manufacturer: Pittsburgh Plate Glass Co.

Acute Toxicity: LD_{50} - 5,000 mg/kg

Precautions:

1. Flammability: High flash point
2. Corrosiveness: Noncorrosive
3. Low if any toxicity to wildlife and fish.

Herbicidal Use: Selective preemergence or early postemergence herbicide.

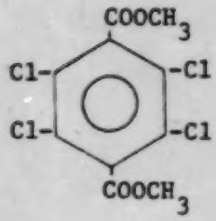
Remarks: Activated by moisture but rapidly lost from the soil at temperature above 75° F. Disrupts cell division.

DACTHAL

Common Name: DCPA

Chemical Name: dimethyl tetrachloroterephthalate

Structural Formula:



Formulation: 50% and 75% wettable powder and 2.5 granules

Manufacturer: Diamond Shamrock Corp.

Acute Toxicity: LD_{50} - greater than 3,000 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. Not toxic to fish at 500 ppm.

Herbicidal Use: A soil active preemergence applied selective herbicide. Uses for many garden crops.

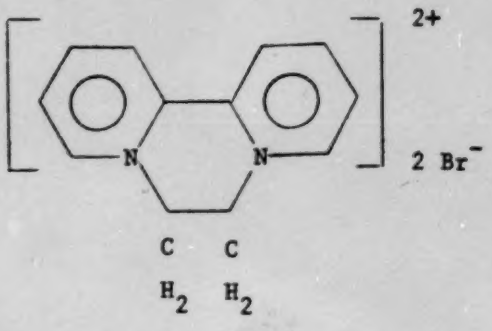
Remarks: Delays maturity of fieldbeans by at least 2 weeks under Wyoming conditions.

DIQUAT

Other Trade Names: Ortho Diquat, Reglone

Chemical Name: 6,7-dihydrodipyrido[1,2-a:2',1'-c]pyrazinedium ion

Structural Formula:



Formulation: 2 lb water soluble cation/gal. (3.73 lb/gal. salt), the cation portion of the molecule is the active ingredient.

Manufacturer: Chevron Chemical Co.
I. C. I. Plant Protection, Ltd., England

Acute Toxicity: LD_{50} - 400 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Dilute concentrations not corrosive to spray equipment. Do not store undiluted diquat in contact with metals. Keep in original container.
3. Wide range of safety to fish and wildlife.
4. Avoid breathing spray mist or getting concentrate on skin.

Herbicidal Use: Noncrop weed killer, a general aquatic herbicide and as a preharvest to killer or desiccant in seed crops.

Remarks: Special precautions should be taken when applying diquat. Inactivated upon contact with soil. Wetting agents increase its activity.

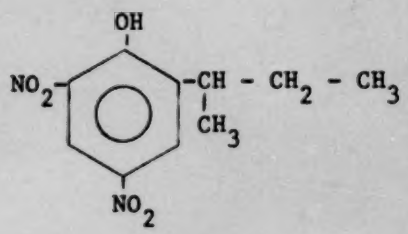
DNBP

Common Name: dinoseb

Other Trade Names: Dow General, Dow Selective, Premerge, Sinox General Sinox W, Sinox PE

Chemical Name: 2-sec-butyl-4,6-dinitrophenol

Structural Formula:



Formulation: 5 to 5.7 lb/gal.emulsifiable concentrate
1 lb/gal. ammonium salt, 3 lb/gal. alkanolamine salt

Manufacturers: The Dow Chemical Co., Niagara Chemical Division
FMC Corp.

Acute Toxicity: LD_{50} - 30 mg/kg

Precautions:

1. Flammability: Premerge minor fire hazard; Dow General flash point 27° C; Dow Selective flammable - flash point 15.5° C.
2. Corrosiveness: Corrosive to equipment.
3. Staining of the skin and minor irritation by very small amounts. Rapid adsorption.

Herbicidal Use: Selective and non-selective contact, not translocated compound used as preemergence, postemergence and as a crop desiccant.

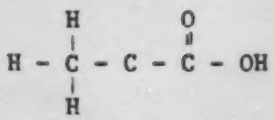
Remarks: Prolonged exposure to the chemical should be avoided. Avoid vapors, mist or contact as it is absorbed through the skin. Organic dye and will turn skin yellow.

DOWPON

Common Name: dalapon

Chemical Name: 2,2,dichloropropionic acid

Structural Formula:



Formulation: 84% water soluble (74% acid equivalent)

Manufacturer: The Dow Chemical Co.

Acute Toxicity: LD_{50} - 9,330 mg/kg

Precautions:

1. Flammability: Nonflammable
2. Corrosiveness: Mildly corrosive to equipment

Herbicidal Use: Translocated selective grass herbicide used as a postemergence foliar spray. Used for annual and perennial grass in sugar beets, corn, potatoes, new legume seedlings, deciduous fruits, and certain stone fruits and nut crops.

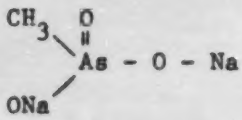
Remarks: A hygroscopic material which loses its herbicidal effects by hydrolisis. Use within two days after mixing with water and keep container tightly closed.

DSMA

Other Trade Names: Ansar 184, Ansar 8100, Ansar DSMA Liquid

Chemical Name: disodium methanearsonate

Structural Formula:



Formulation: 63% soluble powder (100% hexahydrate)

Manufacturer: The Ansul Co., Amchem Products, Inc.

Acute Toxicity: LD_{50} - 1,000 mg/kg

Precautions:

1. Flammability: Nonflammable
2. Corrosiveness: Mildly corrosive
3. Skin irritation varies from very mild to none

Herbicidal Use: Selective control of crabgrass and other weedy grasses in turf. Widely used for control of weeds and grasses in non-crop areas. Mixed with 2,4-D/2,4,5-T to increase conifer and other brush species kill.

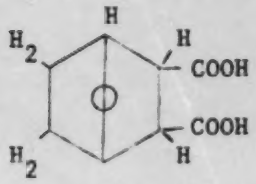
Remarks: DSMA takes up moisture so storage in a dry place is necessary. It is essential to use surfactants with this material.

ENDOTHALL

Mixtures: Hydrothal Plus, Des-i-cate, Endothal-TCA

Chemical Name: 7-orabicyclo [2·2·1] heptane-2,3-dicarboxylic acid

Structural Formula:



Formulation: 0.52, 1.46, 1.5 and 2 lb/gal. soluble concentrate and 5% and 10% granules, formulated as disodium salt and as a number of amine salts.

Aquathal Plus - 22.1% dipotassium salt of endothall plus 25.3% potassium salt of silvex
Des-i-cate - amine salt of endothal plus ammonium sulfate.
Endothal-TCA - 7.1% disodium salt of endothall plus 11.9% sodium salt of TCA.

Manufacturer: Pennwalt Corp.

Acute Toxicity: LD_{50} - 182 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. May be absorbed through the skin, causing light to moderate irritation.

Herbicidal Use: Various formulations are useful as a preemergence and postemergence herbicide, turf herbicide, aquatic herbicide, and harvest aid.

Remarks: Endothall is irritating to the eyes and skin. In water it is generally broken down within 10 days.

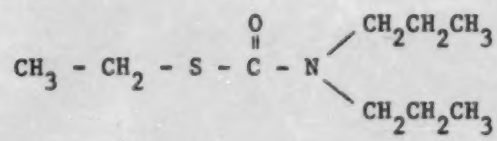
EPTAM

Common Name: EPTC

Other Trade Names: Knoxweed 42 (mixture of EPTC + 2,4-D)

Chemical Name: S-ethyl dipropylthiocarbamate

Structural Formula:



Formulation: 6 lb/gal. emulsifiable concentrate and 10% granules

Manufacturer: Stauffer Chemical Co.

Acute Toxicity: LD_{50} = 1,630 mg/kg

Precautions:

1. Flammability: Flash Point 234° F.
2. Corrosiveness: Noncorrosive.

Herbicidal Use: Selective preemergence herbicide. Federally registered for use on alfalfa, beans (snap and dry), clovers, corn, strawberries, sugar beets, peas, etc., as well as on ornamental plants.

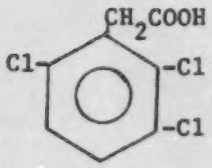
Remarks: Highly volatile - must be incorporated immediately. Good general use herbicide for garden and home owner as well as an agricultural herbicide.

FENAC

Common Name: fenac

Chemical Name: (2,3,6-trichlorophenyl)acetic acid

Structural Formula:



Formulation: 1.5 lb/gal. soluble concentrate

Manufacturer: Amchem Products, Inc.; Hayden Division
Tenneco Chemicals, Inc.

Acute Toxicity: LD_{50} - 1780 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. No toxicity to fish or wildlife when used as recommended.

Herbicidal Use: Preemergence annual and perennial broadleaf and grass control in certain non-cropped areas and aquatic sites. Postemergence perennial broadleaf weed control in non-cropped land.

Remarks: Both foliar and root absorbed but most effective through roots. Being evaluated extensively as a soil injected herbicide for control of field bindweed in Wyoming.

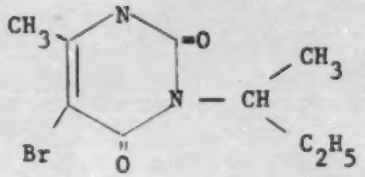
HYVAR

Common Name: bromacil

Other Trade Names: Hyvar X, Hyvar X-L, and Hyvar X-P

Chemical Name: 5-bromo-3-sec-butyl-6-methyluracil (5 bromo-6-methyl-3-(1 methylpropyl)uracil)

Structural Formula:



Formulation: 80% wettable powder

Manufacturer: E. I. DuPont de Nemours & Co.

Acute Toxicity: LD_{50} - 5,200 mg/kg

Precautions:

1. Flammability: Active ingredient and dry formulation no problem; liquid formulation (Hyvar X-L) is combustible mixture - keep away from heat and open flame.
2. Corrosiveness: No problem
3. Low order of toxicity.

Herbicidal Use: Non-cropland areas for control of wide range of annual and perennial grasses and broadleaf weeds, and certain woody species.

Remarks: Less moisture required to activate than many other soil sterilant type compounds. Do not use around the home; very active on trees and shrubs.

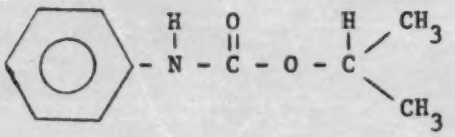
IPC

Common Name: propham

Other Trade Names: Chem-Hoe

Chemical Name: isopropyl carbanilate

Structural Formula:



Formulation: 78% wettable powder, 2 lb/gal. emulsifiable concentrate, 10 + 20% granules, 4 lb/gal. colloidal, 4 lb/gal. flowable.

Manufacturer: PPG Industries

Acute Toxicity: LD_{50} - 5,000 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. Volatile.
4. Low order of toxicity to wildlife and fish.

Herbicidal Use: Selective preplant and preemergence control of wild oats, many annual grasses, and certain broadleaf weeds.

Remarks: Soil must be moist at time of treatment or followed by rainfall or irrigation if applied to dry soil surface. Stops cell division.

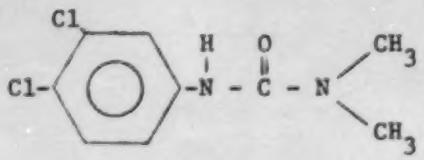
KARMEX

Common Name: diuron

Other Trade Names: Karmex DL

Chemical Name: 3-(3-dichlorophenyl)-1,1-dimethylurea

Structural Formula:



Formulation: 80% wettable powder

Manufacturer: E. I. DuPont de Nemours & Co., Inc.

Acute Toxicity: LD_{50} - 3,400 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. Avoid breathing dust or spray mist.
4. Low order of toxicity.

Herbicidal Use: At high rates, diuron is a general weed killer, with long soil persistence. Low rates selectively control germinating broadleaf and grass weeds in such crops as alfalfa, citrus, apples, cotton, etc.

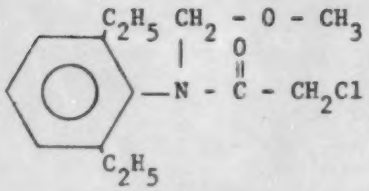
Remarks: Translocation is primarily upward through the xylem. Foliar absorbed when a surfactant is used. Soil persistent especially under arid and semi-arid conditions.

LASSO

Common Name: alachlor

Chemical Name: 2-chloro-2', 6'-diethyl-N-(methoxymethyl) acetanilide

Structural Formula:



Formulation: 4 lb/gal. emulsifiable concentrate, 10% granules

Manufacturer: Monsanto Co.

Acute Toxicity: LD_{50}--1,800 mg/kg

Precautions:

1. Flammability: Combustible. Do not store near heat or open flame.

2. Corrosiveness: No corrosion to No. 316 and No. 304 stainless steel, aluminum and heresite. Corrosive to steel and black iron.

Herbicidal Use: Controls most annual grasses and certain broadleaf weeds, soybeans and corn. Preemergence soil surface treatment; preplant incorporation necessary where furrow irrigation is used.

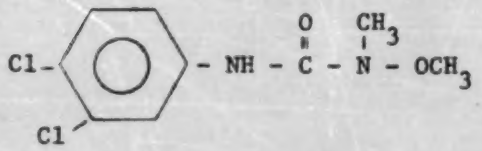
Remarks: Mechanical soil incorporation may be beneficial.

LOROX

Common Name: linuron

Chemical Name: 3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea

Structural Formula:



Formulation: 50% wettable powder

Manufacturer: E. I. DuPont de Nemours & Co.

Acute Toxicity: LD_{50} - 1,500 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. May irritate eyes, nose, throat, and skin.

Herbicidal Use: Selective control of germinating and newly established broadleaf and grassy weeds in crops such as corn, wheat, (Pacific Northwest only), potatoes, carrots, etc. Also used for short-term control of annual weeds in non-cropland areas.

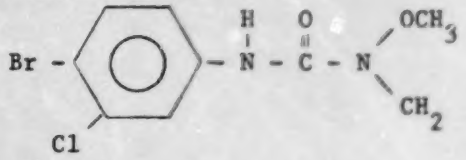
Remarks: More readily absorbed through the root system; less through foliage and stems. Soil residual less than other urea herbicides.

MALORAN

Common Name: chlorbromuron

Chemical Name: 3-[4-bromo-3-chlorophenyl]-1-methoxy-1-methylurea

Structural Formula:



Formulation: 5% wettable powder

Manufacturer: CIBA - Geigy Chemical Co.

Acute Toxicity: LD_{50} - 4280 mg/kg

Precaution:

1. Flammability: Nonflammable
2. Corrosiveness: Noncorrosive
3. Do not inhale smoke from burning containers.

Herbicidal Use: Substituted urea herbicide with preemergence and postemergence activity.

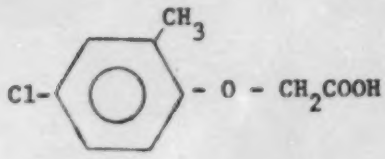
Remarks: Preemergent, postemergent directed before weeds reach 2 to 3 inches high.

MCPA

Other Trade Names: Methoxone, Agroxone 3, Weedone MCPA Ester, Weedar MCPA Concentrate

Chemical Name: 2-methyl-4-chlorophenoxyacetic acid

Structural Formula:



Formulation: 2 and 4 lb/gal soluble and emulsifiable concentrates available as amines, esters, sodium or potassium salts.

Manufacturer: Amchem Products, Inc. - The Dow Chemical Co.

Acute Toxicity: LD_{50} - 700 mg/kg

Precautions:

1. Low toxicity to wildlife and fish.
2. Volatilization relatively stable to light. Salts low.

Herbicidal Use: Selective foliage applied broadleaf killer, similar to 2,4-D, also as a growth regulator for preharvest drop of specific apples. More selective than 2,4-D at equal rates on cereals, legumes, and flax.

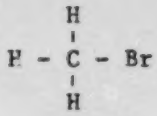
Remarks: Usually less toxic and more selective than 2,4-D. Readily translocated in plants.

METHYL BROMIDE

Other Trade Names: Dowfume, MC-2, Pestmaster, Soil Fumigant-1

Chemical Name: Methyl bromide

Structural Formula:



Formulation: Liquid under pressure, methyl bromide 98%, chloropicrin 2%.

Manufacturers: The Dow Chemical Co.
Michigan Chemical Corp.

Acute Toxicity: LD_{50} - 1 mg/kg. Upper limit 17 ppm in air.

Precautions:

1. Highly volatile.
2. Methyl bromide gas is poisonous to humans and animals and effects of exposure are cumulative.

Herbicidal Use: Used to sterilize seed beds, plant beds, potting soils, greenhouse beds, and garden soils. Will control nearly all perennial weeds, most weed seeds, nematodes, wireworms, grubs, and many soil-borne diseases.

Remarks: Applied on plant beds under a gasproof cover. Acts within 48 hours. Extreme caution is needed in handling this material.

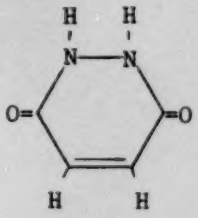
MH

Common Name: Malaeic hydrazide

Other Trade Names: MH-30, MH-30T, Sucker-stuff, Sprout-stop, Retard

Chemical Name: 1,2-dihydro-3,6-pyridazinedione

Structural Formula:



Formulation: 1.5 and 3 lb/gal. soluble concentrate

Manufacturers: Uniroyal Chemical Division, Uniroyal, Inc.
The Ansul Co.

Acute Toxicity: LD_{50} - 6,950 mg/kg

Precautions:

1. Flammability: None
2. Corrosiveness: Do not use concentrate through brass nozzles.

Herbicidal Use: Used for many purposes as a growth inhibitor and a preemergence or postemergence selective herbicide.

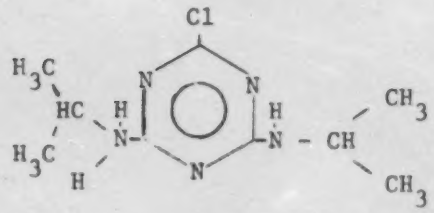
Remarks: Inhibits cell division but not cell enlargement. Used to suppress the growth of grasses and some broadleaf plants. Rate of absorption is greater with high humidity.

MILOGARD

Common Name: propazine

Chemical Name: 2-chloro-4,6-bis(isopropylamino)-s-triazine

Structural Formula:



Formulation: 80% wettable powder

Manufacturer: CIBA-Geigy Corp.

Acute Toxicity: LD_{50} - >5,000 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. Very low order of toxicity to wildlife and fish.

Herbicidal Use: Selective preemergence control of broadleaf and grassy weeds in sorghum.

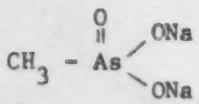
Remarks: Absorbed through plant roots. Very little post-emergence activity.

MSMA

Other Trade Names: Trans-Vert, Ansar 170, Ansar 159, Ansar 529 H.C.

Chemical Name: methanearsonic acid

Structural Formula:



Formulation: 4 and 4.15 lb/gal. soluble concentrates

Manufacturer: Amchem Products, Inc.
The Ansul Co.

Acute Toxicity: LD_{50} - 1,800 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Mildly corrosive.
3. Skin irritation varies from mild to none.

Herbicidal Use: Widely used for controlling broadleaf and grassy weeds in non-cropped areas. One of first major uses was a selective herbicide for postemergence control of crabgrass and other weedy grasses in turf.

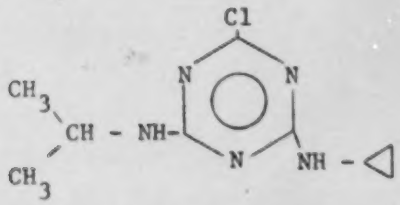
Remarks: MSMA contains a surfactant, no need to add additional. Best results are obtained when air temperature above 80° F. Almost completely inactivated in soil by surface adsorption and ion exchange.

OUTFOX

Common Name: cyprazine

Chemical Name: 2-chloro-4-cyclopropylamino-6-isopropylamino-1,3,5-triazine

Structural Formula:



Formulation: 1 lb/gal. emulsifiable liquid

Manufacturer: Gulf Oil Corp.

Acute Toxicity: LD_{50} - 1,200 ± 200 mg/kg

Precautions: 1. Flammability: Nonflammable.

2. Corrosiveness: Noncorrosive.

Herbicidal Use: Selective postemergence herbicide for control of common seedling weeds in corn.

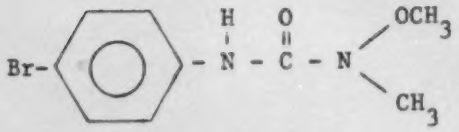
Remarks: Characteristic of other S-triazine herbicides. Soil persistence under semi-arid conditions may result in carryover damage to sensitive crops in rotation.

PATORAN

Common Name: metobromuron

Chemical Name: 3-(p-bromophenyl)-1-methoxy-1-methylurea

Structural Formula:



Formulation: 50% wettable powder

Manufacturer: CIBA - Geigy Corp.

Acute Toxicity: LD_{50} - 2,000 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.

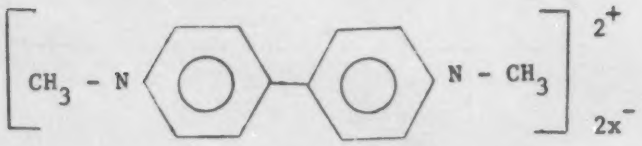
Herbicidal Use: Preemergent soil surface applied immediately after planting. Useful for weed control on potatoes, fieldbeans, etc. Also ornamentals.

Remarks: Soil active compound.

PARAQUAT

Chemical Name: 1,1'-dimethyl-4,4'-bipyridinium ion [as dichloride or bis (methyl sulfate) salts]

Structural Formula:



where x^- = Cl or CH_3SO_4

Formulation: 2 lb water soluble cation/gal, the cation portion of the molecule is the active ingredient.

Manufacturer: Chevron Chemical Co.

Acute Toxicity: LD_{50} - 157 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Not corrosive to commonly used spray equipment.
3. Generally safe to wildlife and fish.
4. Avoid breathing spray mist or getting concentrate on skin. Repeated exposure to skin will increase ease of absorption of the chemical.

Herbicidal Use: Weed control during establishment of grass seed crops. General contact herbicide for non-crop usages, as orchard weed control. Crop desiccant and defoliant on cotton and potatoes.

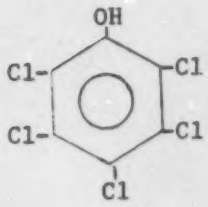
Remarks: Material is toxic if swallowed, inhaled, or absorbed through the skin. Use protective clothing.

PENTACHLOROPHENOL

Common Name: PCP

Chemical Name: Pentachlorophenol

Structural Formula:



Formulation: 85 and 88% wettable powder, 5, 21 and 41% solutions, and 40% flakes

Manufacturer: Monsanto Co
The Dow Chemical Co.

Acute Toxicity: LD_{50} - 78 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. Moderate irritation, even a burn, depending on length of contact. Dusts are very irritating to upper respiratory tract and eyes.

Herbicidal Use: General contact weed killer for general vegetation control. Also used as a wood preservative and to "fortify" oils.

Remarks: Corrosive to rubber.

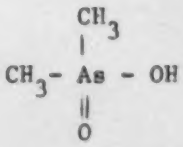
PHYTAR 138

Common Name: cacodylic acid

Other Trade Names: Phytar 560, Silvisar 510

Chemical Name: hydroxydimethylarsine oxide

Structural Formula:



Formulation: 24% soluble solution (Phytar 560), 50% soluble solution (Silvisar 510)

Manufacturer: The Ansul Co.

Acute Toxicity: LD_{50} - 830 mg/kg

Precaution:

1. Flammability: Nonflammable.
2. Corrosiveness: Mildly corrosive.
3. Skin irritation varies from very mild to none.

Herbicidal Use: Postemergence non-selective contact herbicide. Commercial uses include: lawn renovation, general weed control in non-crop areas such as around buildings, near perennial ornamentals, along fence rows, and spot control of noxious weeds. Silvisar is used for control of trees (thinning, undesirable trees etc.) by injection.

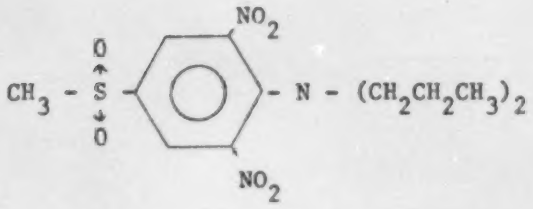
Remarks: The phytotoxic properties of this herbicide are quickly inactivated on contact with soils.

PLANAVIN

Common Name: nitralin

Chemical Name: 4-(methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline

Structural Formula:



Formulation: 75% wettable powder, 4 lb/gal. water dispensable liquid

Manufacturer: Shell Chemical Co. - Agricultural Chemicals Div.

Acute Toxicity: LD_{50} - 2,000 mg/kg

Precautions:

1. Flammability: Technical material is flammable.
2. Corrosiveness: Noncorrosive.
3. Not toxic to wildlife or fish when applied as directed.

Herbicidal Use: Used as a selective herbicide in drybeans, and several garden crops. Is a preemergence herbicide which needs soil incorporation or rainfall for activation.

Remarks: Application and incorporation may be either preplanting, postplanting, or layby for specific crops.

POLYBOR

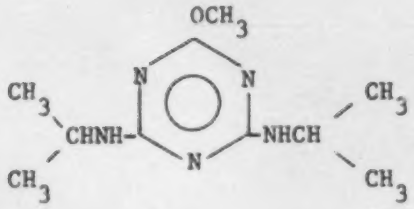
Chemical Name:	disodium octaborate tetrahydrate
Molecular Formula:	$Na_2B_8O_{13}\cdot 4H_2O$
Formulation:	
Manufacturer:	United States Borax and Chemical Co.
Acute Toxicity:	LD_{50} - 2,000 mg/kg
Precautions:	1. Flammability: Nonflammable. 2. Corrosiveness: Not a hazard.
Herbicidal Use:	Non-selective vegetation control; adapted to preventing weed emergence under asphalt.
Remarks:	Persistence at recommended rates - one year. Rapid leaching in high rainfall areas.

PRAMITOL

Common Name: prometone

Chemical Name: 2,4-bis(isopropylamino)-6-(methylthio)-s-triazine

Structural Formula:



Formulation: 25% emulsifiable concentrate (approx. 2 lb/gal.)

Manufacturer: CIBA-Geigy Corp.

Acute Toxicity: LD_{50} - 2,980 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. Very low toxicity to wildlife and fish.

Herbicidal Use: Non-selective preemergence and postemergence herbicide for use in non-cropland.

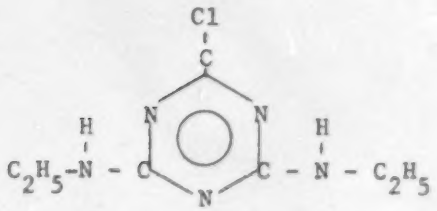
Remarks: Activity through both foliage and roots.

PRINCEP

Common Name: simazine

Chemical Name: 2-chloro-4,6-bis(ethylamino)-s-triazine

Structural Formula:



Formulation: 80% wettable powder, 4% granules and 4 lb/gal. water dispersible liquid.

Manufacturer: CIBA-Geigy Corp.

Acute Toxicity: LD_{50} - 5,000 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. Moderately to slightly toxic to man from standpoint of ingestion of single oral doses.
4. Non-volatile.
5. Very low toxicity to wildlife and fish.

Herbicidal Use: Selective herbicide for control of grassy and broadleaf weeds in corn, deciduous fruits, established alfalfa, perennial grasses grown for seed and pasture, ornamentals and nursery plantings. At high rates it is also used as a non-selective herbicide for vegetation control in non-crop land.

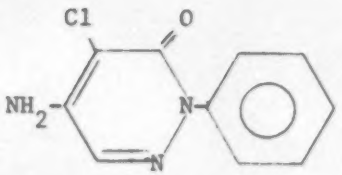
Remarks: Moisture needed for activation; is also a persistent soil residual compound.

PYRAMIN 80W

Common Name; pyrazon

Chemical Name: 5-amino-4-chloro-2-phenyl-3(2H)pyridazinone

Structural Formula:



Formulation: 80% wettable powder

Manufacturers: Badische Anilin
Soda-Fabrik

Acute Toxicity: LD_{50} - 3,000 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. Non-volatile.
4. Not toxic to fish.

Herbicidal Use: Control of annual broadleaf weeds in sugarbeets and red beets. Control of annual grasses is not consistently obtained.

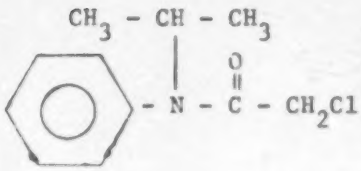
Remarks: Used on both preplant and postemergence on sugarbeets. Needs to be mixed with a grass herbicide. Pyramin Plus is a combination of Pyramin + dalapon + wetting agent for postemergence use on sugarbeets.

RAMROD

Common Name: propachlor

Chemical Name: 3-chloro-N-isopropylacetanilide

Structural Formula:



Formulation: An emulsifiable concentrate, 65% wettable powder, and 20% granules

Manufacturer: Monsanto Co.

Acute Toxicity: LD_{50} - 1,200 mg/kg

Precautions:

1. Corrosiveness: Corrosive to ordinary metals.
2. Irritating to skin, eyes, nose and throat.

Herbicidal Use: Preemergence soil surface treatment; early post-emergence; preplant incorporated with furrow irrigation for use in corn, sorghum and soybeans.

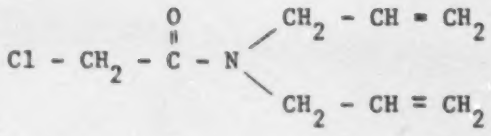
Remarks: Mechanical incorporation may be beneficial. Wear protective clothing.

RANDOX

Common Name: CDAA

Chemical Name: N,N-diallyl-2-chloroacetamide (2-chloro-N,N-diallylacetamide)

Structural Formula:



Formulation: 4 lb/gal. emulsifiable concentrate and 10% granules

Manufacturer: Monsanto Co.

Acute Toxicity: LD_{50} - 750 mg/kg

Precaution:

1. Flammability: No special precautions.
2. Corrosiveness: Corrosive to ordinary metals.
3. Irritating to skin.

Herbicidal Use: Control of germinating seeds of annual grasses and certain broadleaf weeds in corn, sorghum, dry beans and some ornamentals.

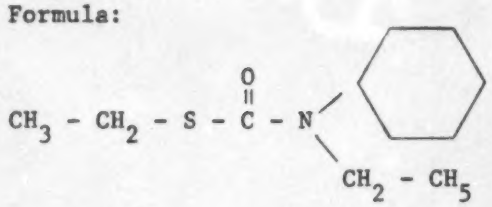
Remarks: Irritating to eyes and skin. May be absorbed through the skin.

RO-NEET

Common Name: cycloate

Chemical Name: S-ethyl N-ethylthiocyclohexanecarbamate

Structural Formula:



Formulation: 6 lb/gal. emulsifiable concentrate, 10% granules

Manufacturer: Stauffer Chemical Co.

Acute Toxicity: LD_{50} - 3,160 mg/kg

Precaution:

1. Flammability: Flash point - 282° F.
2. Corrosiveness: Noncorrosive

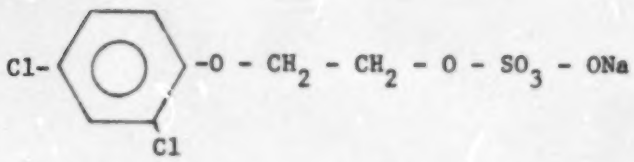
Herbicidal Use: Preplant soil incorporated sugar beet and spinach herbicide.

Remarks: Incorporate immediately in the top 2 to 3 inches of soil. Cycloate absorbed by seed and stem tissue of seedlings.

SESONE

Chemical Name: 2-(2,4-dichlorophenoxy)ethyl sodium sulfate

Structural Formula:



Formulation: 90% soluble powder

Manufacturer: Amchem Products, Inc.

Acute Toxicity: LD_{50} - 1,400 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. Non-volatile.
4. Not toxic to fish and wildlife at recommended uses.

Herbicidal Use: Annual grass and broadleaf weed control in strawberries, evergreens, shrubs, trees, and flowers.

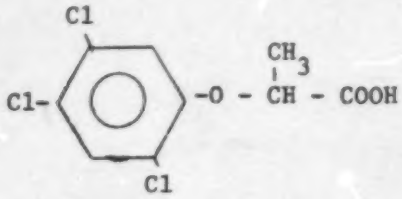
Remarks: Sesone does not harm plants when applied to the foliage, but when in contact with the soil, microorganisms convert to 2,4-D. Adequate soil moisture is essential.

SILVEX

Other Trade Names: Kuron, 2,4,5-TP

Chemical Name: 2-(2,4,5-trichlorophenoxy)propionic acid

Structural Formula:



Formulation: 4 lb/gal. emulsifiable concentrate

Manufacturer: Amchem Products, Inc.
The Dow Chemical Co.

Acute Toxicity: LD_{50} - 500 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. Low volatility.
4. Not ordinarily toxic to aquatic or other animals when used as recommended.

Herbicidal Use: For control of woody plants, certain herbaceous, and aquatic weeds. Recommended in Wyoming for prickly-pear cactus control. Also, special item products for weed control in lawns.

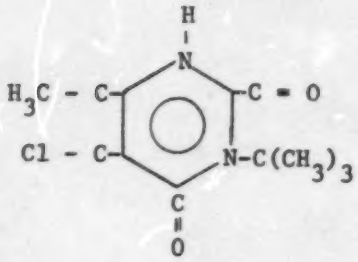
Remarks: Similar to 2,4-D. Maybe less selective, longer soil residual and more active on some weeds than the 2,4-D compounds.

SINBAR

Common Name: terbacil

Chemical Name: 3-tert-butyl-5-chloro-6-methyluracil

Structural Formula:



Formulation: 80% wettable powder

Manufacturer: E. I. DuPont de Nemours & Co., Inc.

Acute Toxicity: LD_{50} - 5,000 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Not a problem.
3. May irritate eyes, nose, throat, and skin.
4. Low order of toxicity.

Herbicidal Use: Selective control of many annual and some perennial weeds in apples, peaches, mint, etc. Being evaluated for annual grassy and broadleaved weed control in dormant alfalfa in Wyoming.

Remarks: Shows promise for selective weed control in several crops.

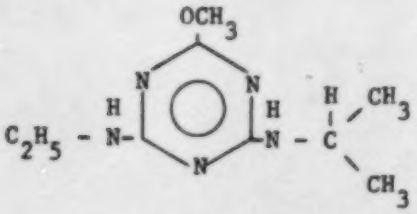
SODIUM CHLORATE

Other Trade Names:	Atlacide, General Chemical Chlorate, Tumbleaf, United Chemical Defoliant No. 1 and others.
Chemical Name:	sodium chlorate
Molecular Formula:	$NaClO_3$
Formulation:	40% wettable powder, 4, 19 and 28% liquid, 12 and 33% dust, 98% active material in powder form, also formulated with borates, sodium carbonate, calcium chloride, magnesium chloride, monuron, 2,4-D and others.
Manufacturers:	American Potash & Chemical Corp. Rhodia Inc. - Chipman Division Pennwalt Corp PPG Industries
Acute Toxicity:	LD_{50} - 5,000 mg/kg
Precautions:	1. Flammability: Fire and explosion hazard when mixed with organic substances. 2. Toxicity to skin and through inhalation. 3. Contaminated clothing should be changed at once. 4. Toxic to fish.
Herbicidal Use:	Used as a soil sterilant for control of several deep rooted perennials and as a defoliant.
Remarks:	High rates of 1 to 8 lb/sq. rod. Easily leached from the soil.

SUMITOL

Chemical Name: 2-sec-butylamino-4-ethylamino-6-methoxy triazine

Structural Formula:



Formulation: 80% wettable powder and 3.0 lb/gal. Emulsifiable concentrate

Manufacturer: CIBA-Geigy Corp.

Acute Toxicity: LD_{50} - 1,000 ± 100 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. Low order of toxicity to wildlife and fish.

Herbicidal Use: Being developed for use on established alfalfa.

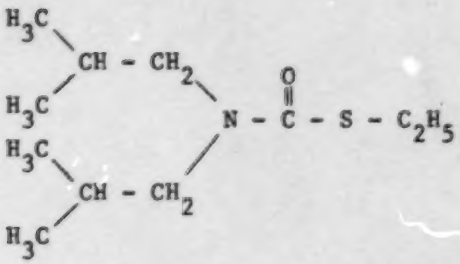
Remarks: Reasonably new compound that does not have EPA clearance for use on alfalfa as yet.

SUTAN

Common Name: butylate

Chemical Name: S-ethyl diisobutylthiocarbamate

Structural Formula:



Formulation: 6 lb/gal. emulsifiable concentrate, 10% granules

Manufacturer: Stauffer Chemical Co.

Acute Toxicity: LD_{50} - 5,366 mg/kg

Precautions:

1. Flammability: Flash point - 227° F.
2. Corrosiveness: Noncorrosive.

Herbicidal Use: Selective preplant herbicide for use on sweet and field corn. Is mixed with other herbicides (AAtrex) for wider spectrum of weed control.

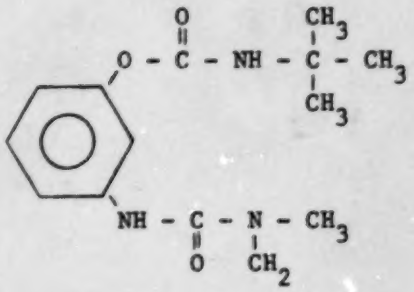
Remarks: Must be incorporated immediately after application due to volatility.

TANDEX

Common Name: karbutilate

Chemical Name: m-(3,3- dimethylureido)phenyl tert-butyl carbamate

Structural Formula:



Formulation: 80% wettable powder, 4% granular

Manufacturer: Niagara Chemical Div. - FMC Corp.

Acute Toxicity: LD_{50} - 3,000 mg/kg

Precautions:

1. Flammability: Not flammable.
2. Corrosiveness: Noncorrosive.
3. Non-toxic to wildlife and fish.

Herbicidal Use: Control of annual and perennial broadleaf weeds and grasses, as well as woody species. Useful for railroad, highway and utility rights-of-way, industrial sites and other non-cropped areas.

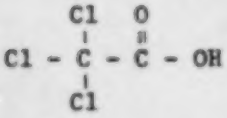
Remarks: Addition of surfactant improves postemergence activity. Avoid use on soils with a pH greater than 8.

TCA

Other Trade Names: Sodium TCA Inhibited

Chemical Name: Trichloroacetic acid

Structural Formula:



Formulation: 90% sodium TCA, 95% solubilized pellets

Manufacturer: The Dow Chemical Co.

Acute Toxicity: LD_{50} - 5,000 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Mildly corrosive to equipment.
3. Low order of toxicity to wildlife and fish.
4. Dust very irritating to nose and throat if inhaled.

Herbicidal Use: For control of grass seedlings and certain established perennial grasses and cattails.

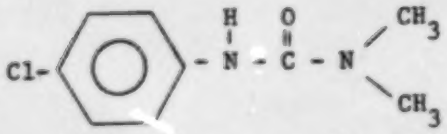
Remarks: TCA is a root absorbed readily leached compound. Being hygroscopic it is essential to keep container tightly closed.

TELVAR

Common Name: monuron

Chemical Name: 3-(p-chlorophenyl)-1,1-dimethylurea

Structural Formula:



Formulation: 80% wettable powder

Manufacturer: E. I. DuPont de Nemours & Co., Inc.

Acute Toxicity: LD_{50} - 3,600 mg/kg

Precautions:

1. Flammability: No problem.
2. Corrosiveness: No problem.
3. Low order of toxicity.

Herbicidal Use: At low rates selectivity in cotton, asparagus, etc. At higher rates is a general weed killer with soil persistence.

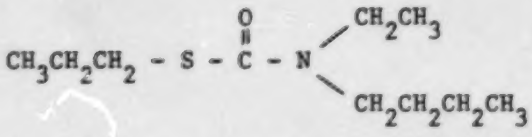
Remarks: Soil persistent with relatively low solubility. Do not use around trees, hedges, etc.

TILLAM

Common Name: pebulate, PEBC

Chemical Name: S-propyl butylethylthiocarbamate

Structural Formula:



Formulation: 6 lb/gal. emulsifiable concentrate, 10% granules

Manufacturer: Stauffer Chemical Co.

Acute Toxicity: LD_{50} - 1,200 mg/kg

Precautions:

1. Flammability: Flash Point 248° F.
2. Corrosiveness: Noncorrosive.

Herbicidal Use: Selective preemergence, soil incorporated herbicide for control of annual grass and broadleaved weeds in sugar beets and tomatoes.

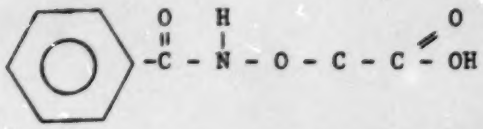
Remarks: For optimum weed control, Tillam must be incorporated immediately after application.

TOPCIDE

Common Name: benzadox

Chemical Name: (benzamidooxy)acetic acid

Structural Formula:



Formulation: 2 lb/gal. emulsifiable concentrate

Manufacturer: Gulf Oil Co.

Acute Toxicity: LD_{50} - about 5,600 mg/kg

Herbicidal Use: For postemergence control of kochia in sugar beets.

Remarks: Apply when kochia is in the rosette stage and the majority of kochia plants are about one inch in diameter. If temperature is below 55° F. at time of treatment, or rain occurs within 8 hours, control is reduced.

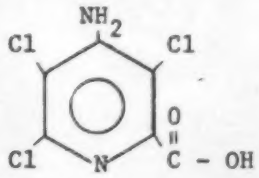
TORDON

Other Trade Names: Tordon 212 mixture, Tordon Beads, Tordon 10K Pellets, Tordon 22K

Common Name: picloram

Chemical Name: 4-amino-3,5,6-trichloropicolinic acid

Structural Formula:



Formulation: 2 lb/gal. soluble concentrate, Tordon 212 (1 lb picloram + 2 lb 2,4-D amine salt) 2% beads plus borate.

Manufacturer: The Dow Chemical Co.

Acute Toxicity: LD_{50} - 8,200 mg/kg

Precautions:

1. Flammability: Tordon-22K flash point 114° F. Pellets and beads - nonflammable.
2. Corrosiveness: Mildly corrosive.
3. Very low order of toxicity to wildlife and fish.
4. Many times more toxic than 2,4-D.

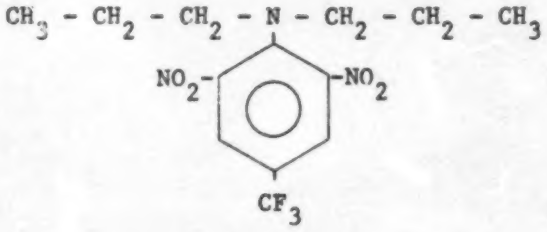
Herbicidal Use: For general woody plant control and control of most deep-rooted perennials. Most grasses are resistant; broadleaf weed control in grass crops is feasible.

Remarks: The high order of broadleaf plant susceptibility requires careful application which precludes soil and water contamination.

TREFLAN

Common Name: trifluralin

Chemical Name: α,α,α -trifluro-2,6-dinitro-N,N-dipropyl-p-toluidine



Formulation: 4 lb/gal. emulsifiable concentrate, 5% granules

Manufacturer: Elanco Products Co. (Div. of Eli Lilly & Co.)

Acute Toxicity: LD_{50} - 3,700 mg/kg

Precautions:

1. Flammability: Technical material not flammable. Use ordinary precautions for volatile solvents in formulation.
2. Corrosiveness: Noncorrosive.
3. Volatile.
4. No hazard to mammals and birds, toxic to fish if placed directly in water.

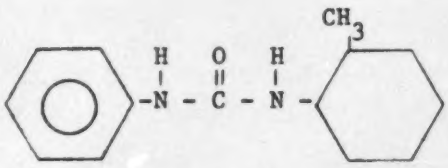
Herbicidal Use: Preemergence herbicide which must be incorporated immediately. Residual activity from higher rates of application may be a problem with certain sensitive crops following in rotation. Is not active on plants in the Nightshade family.

TUPERSAN

Common Name: siduron

Chemical Name: 1-(2-methoxycyclohexyl)-3 phenylurea

Structural Formula:



Formulation: 50% wettable powder

Manufacturer: E. I. DuPont de Nemours & Co., Inc.

Acute Toxicity: LD_{50} - >5,000 mg/kg

Precautions:

1. Flammability: No problem.
2. Corrosiveness: No problem.
3. May irritate eyes, nose, throat, and skin.
4. Low order of toxicity.

Herbicidal Use: Selective control of certain germinating annual weedy grasses (crabgrass), in newly seeded or established plantings of bluegrass, fescue, smooth brome, etc.

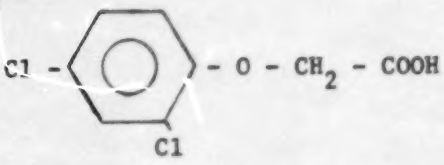
Remarks: Most readily absorbed through root system. Apply as a preemergence treatment to bare ground following spring seeding, or to new fall seedlings or established turf in the spring.

2,4-D

Other Trade Names: Weedone 638, DMA-4, Weedar 64 and others

Chemical Name: (2,4-dichlorophenoxy)acetic acid

Structural Formula:



Formulation: Numerous acids, salts (amines usually) and esters. Sold as liquids, water soluble powders, dusts, granules and pellets.

Manufacturer: The Dow Chemical Co., Rhodia Inc.
Chipman Division, Amchem Products, Inc.

Acute Toxicity: LD_{50} - 500 mg/kg

Precautions:

1. Flammability: Aqueous, nonflammable.
2. Corrosiveness: Noncorrosive.
3. Not harmful to wildlife under use conditions.
4. Some formulations may cause irritation.

Herbicidal Use: Widely used foliar absorbed, translocated phenoxy herbicide for broadleaf weed control in cereal crops, turf, pastures and non-crop land.

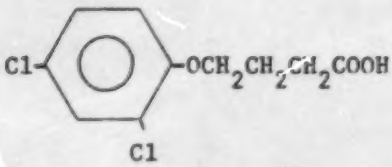
Remarks: 2,4-D is effective against many annual and perennial broadleaf weeds. Ester formulations are most volatile, the amine least volatile. Cheap compared to other compounds.

2,4-DB

Other Trade Names: Butoxone SB, Butoxone Ester

Chemical Name: 4-(2,4-dichlorophenoxy)butyric acid

Structural Formula:



Formulation: 2 lb/gal. emulsifiable and soluble concentrates formulated as amine salts and esters.

Manufacturers: Amchem Products, Inc.
Rhodia Inc. - Chipman Div.

Acute Toxicity: LD_{50} - 500 mg/kg

Precautions:

1. Flammability: Aqueous, nonflammable.

2. Corrosiveness: Noncorrosive.

Herbicidal Use: Selective postemergence translocated herbicide for broadleaf weed control in seedling legumes.

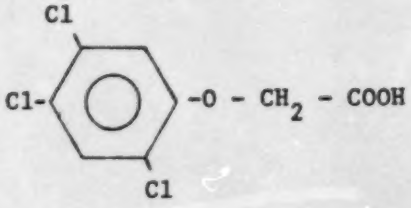
Remarks: Beta oxidation to 2,4-D.

2,4,5-T

Other Trade Names: Several

Chemical Name: (2,4,5-trichlorophenoxy)acetic acid

Structural Formula:



Formulation: Amines, salts and esters as liquid concentrates from 1 to 6 lb/gal.

Manufacturers: The Dow Chemical Co.
Rhodia Inc., - Chipman Div.

Acute Toxicity: LD_{50} - 300 mg/kg

Precautions:

1. Flammability: Technical material not flammable. Flammability depends upon formulation.
2. Corrosiveness: Noncorrosive.
3. Low volatility.
4. Hazards to wildlife from 2,4,5-T when used as recommended is negligible.

Herbicidal Use: For general control of woody plants, brush, and broadleaf weeds.

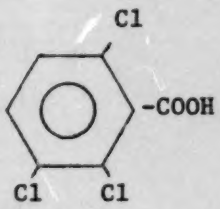
Remarks: Less selective than 2,4-D but more effective on certain woody plants.

2,3,6-TBA

Other Trade Names: Benzac 1281, Trysben 200, Fen-All

Chemical Name: 2,3,6-trichlorobenzoic acid

Structural Formula:



Formulation: 2 lb/gal. soluble concentrate

Manufacturers: I. E. DuPont de Nemours & Co., Inc.
Amchem Products, Inc.
Heyden Div., Tennaco Chemical, Inc.

Acute Toxicity: LD_{50} - 1,644 mg/kg

Precautions:

1. Flammability: Nonflammable.
2. Corrosiveness: Noncorrosive.
3. Non-volatile.
4. Low order of toxicity.

Herbicidal Use: Primarily for control of broadleaf, deep-rooted perennial weeds. Also for non-selective control in non-cropland for certain weedy plants and vines.

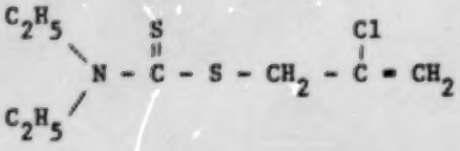
Remarks: Both root and foliage active but most active through the roots. Avoid spray drift on susceptible broadleaf crops.

VEGEDEX

Common Name: CDEC

Chemical Name: 2-chloroallyl diethyldithiocarbamate

Structural Formula:



Formulation: 4 lb/gal. emulsifiable concentrate, 20% granules

Manufacturer: Monsanto Co.

Acute Toxicity: LD_{50} - 850 mg/kg

Precaution:

1. Flammability: Relatively non-flammable.
2. Corrosiveness: Noncorrosive to metals.

Herbicidal Use: Used mainly in the vegetable growing areas.

Remarks: Irritating to eyes and skin. Will not control established weeds.

SECTION VIII

The Classification of Herbicides

A. Inorganic Chemicals

1. Sulphamates — $-O-SO_2-$

   a. Ammonium sulphamate — $[(NH_4)-O-SO_2-NH_2]$

2. Sulphates — $-SO_4$

   a. Ammonium sulphate — $[(NH_4)_2SO_4]$

   b. Cupric sulphate — $[(CuSO_4]$

   c. Ferrous sulphate — $[FeSO_4]$

   d. Magnesium sulphate/potassium chloride — $[MgSO_4/KCl]$

   e. Sulphuric acid — $[H_2SO_4]$

3. Cyanates — $-CN-$

   a. Calcium cyanamide — $[CaCN_2]$

   b. Ammonium thiocyanate — $[NH_4CNS]$

   c. Potassium cyanate — $[KCNO]$

4. Arsenates -As-

a. Sodium arsenite [Na_3AsO_3(+$NaAsO_2$ + $Na_4As_2O_5$)]

b. Calcium arsenate [$Ca_3(AsO_4)_2$]

c. Arsenic trioxide [As_2O_3[O=As-O-As=O]]

5. Nitrates -NO_3-

a. Sodium nitrate [$NaNO_3$]

b. Cupric nitrate [$Cu(NO_3)_2$]

6. Chlorates -Cl-

a. Sodium chlorate [$NaClO_3$]

b. Sodium chloride [NaCl]

7. Borates -B-

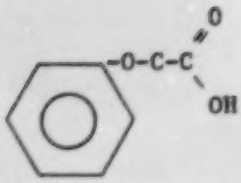
a. Sodium tetraborate [$Na_2B_4O_7$]

B. Organic Chemicals

1. Non-nitrogenous compounds

a. Carboxylic - Aromatic Compounds

1. Phenoxyacetic Acids



a. 4 CPA [4 chlorophenoxyacetic acid]

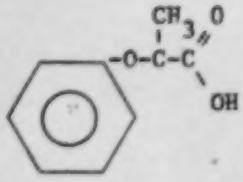
b. MCPA [4-chloro-2-methylphenoxyacetic acid]

c. 2,4-D [2,4-dichlorophenoxyacetic acid]

d. 3,4-DA [3,4-dichlorophenoxyacetic acid]

e. 2,4,5-T [2,4,5-trichlorophenoxyacetic acid]

2. Phenoxypropionic Acid



a. 2-(4-CPP) [2-(4-chlorophenoxy)propionic acid]

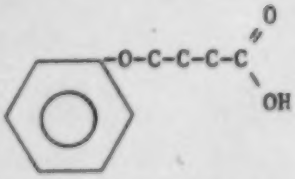
b. 2-(2,4-DP) [2-(2,4-dichlorophenoxy)propionic acid]

c. 2-(3,4-DP) [-2-(3,4-dichlorophenoxy)propionic acid]

d. 2-(MCPP) [2-(4-chloro-2-methylphenoxy)propionic acid]

e. Silvex (2,4,5-TP) [2-(2,4,5-trichlorophenoxy)propionic acid]

3. Phenoxybutyric Acids



a. 4-(4-CPB) [4-(4-chlorophenoxy)butyric acid]

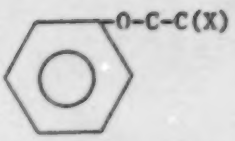
b. MCPB [4-(4-chloro-2-methylphenoxy)butyric acid]

c. 2,4-DB [4-(2,4-dichlorophenoxy)butyric acid]

d. 4-(3,4-DB) [4-(3,4-dichlorophenoxy)butyric acid]

e. 4-(2,4,5-TB) [4-(2,4,5-trichlorophenoxy)butyric acid]

4. Phenoxyethyl Compounds (X)

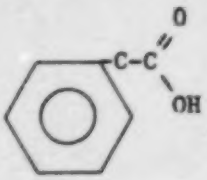


a. Sesone (2,4-DES) [2,4-dichlorophenoxyethyl hydrogen sulphate]

b. MCPES [sodium 4-chloro-2-methylphenoxyethyl sulphate]

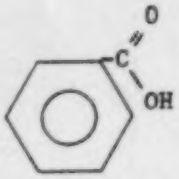
c. 2,4-DEB [2,4-dichlorophenoxyethyl benzoate]

5. Phenylacetic Acid



a. Fenac [2,3,6-trichlorophenylacetic acid]

6. Benzoic Acid



a. 2,3,6-TBA [2,3,6-trichlorobenzoic acid]

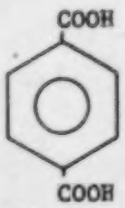
b. 2,3,5,6-TBA [2,3,5,6-tetrachlorobenzoic acid]

c. amiben [3,amino-2,5-dichlorobenzoic acid]

d. dicamba [2-methoxy-3,6-dichlorobenzoic acid] or [3,6-dichloro-o-anisic acid]

e. tricamba [2-methoxy-3,5,6-trichlorobenzoic acid] or [3,5,6-dichloro-o-anisic acid]

7 Phthalic Acid



a. TCTP [dimethyl ester of tetrachloroterephthalic acid]

b. Endothal [disodium 3,6-endoxohexahydrophthalic acid]

c. NPA [N-1-naphthylphthalamic acid]

b. Aliphatic Acids (Open Chain)

1. Acetic Acid

a. -- [sodium-monochloroacetic acid]

b. TCA [trichloroacetic acid]

c. Benzadox [benzamido-oxyacetic acid[(Topcide)

2. Propionic Acid

a. Dalapon [2,2-dichloropropionic acid]

b. 2,2,3-TPA [2,2,3-trichloropropionic acid]

c. TFP [2,2,3,3-tetrafluoropropionic acid]

3. Butyric Acid

a. DBA [sodium 2,2-dichlorobutyric acid]

c. Organic - Metalic

a. *Ansar 138 [dimethyl-arsonic acid]

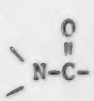
b. DSMA [disodium-methylarsonic acid]

c. MSMA [monosodium-methylarsonic acid]

2. Nitrogen Compounds

a. Non-Ringed

1. Amides



a. Allidochlor [N,N-diallyl-2-chloroacetamide]

b. Diphenamide [N,N-dimethyl-2,2-diphenylacetamide]

c. Kerb [N-(1,1-dimethylpropinyl)-3,5-dichloro-benzamide]

d. Propanil [N-(3,4-dichlorophenyl)-propanamide]

e. Dicryl [N-(3,4-dichlorophenyl)-methacrylamide]

f. Solan [N-(3-chloro-4-methylphenyl)-2-methylpentanamide]

g. propachlor [N-isopropyl-α-chloroacetanilide]

h. prynachlor [N-butyn-(1)-yl-(3)-α-chloroacetanilide]

i. alachlor [N-methoxymethyl-α-chloroaceto-2,6-diethyl-anilide]

j. Delachlor [N-isobutoxymethyl-α-chloraceto-2,6-dimethyl-anilide]

k. NPA or Naptalam [N-1-naphthyl phthalamic acid]

2. Ureas $>N-\overset{O}{\overset{\|}{C}}-N<$

a. Siduron [1-(2-methylcyclohexyl)-3-phenylurea]

b. fenuron [1,1-dimethyl-3-phenylurea]

c. fenuron TCA [1,1-dimethyl-3-phenylurea mono(trichloroacetate]

d. monuron [3-(p-chlorophenyl)-1,1-dimethylurea]

e. monuron TCA [3-(p-chlorophenyl)-1,1-dimethylurea mono(trichloroacetate]

f. fluometuron [1,1-dimethyl-3-(α,α,α-trifluoro-m-tolyl)urea]

g. Tandex [N-(3-(N-tert.-butylcarbamoyloxy)-phenyl)-N',N'-dimethylurea]

h. diuron [3-(3,4-dichlorophenyl)-1,1-dimethylurea]

i. neburon [1-butyl-3-(3,4-dichlorophenyl)-1-methylurea]

j. chloroxuron [3-(p-(p-chlorophenoxy)phenyl)-1,1-dimethyl-urea]

k. cycluron [3-cyclooctyl-1,1-dimethylurea]

l. norea [3-(hexahydro-4,7-methanoindan-5-yl)-1,1-dimethylurea]

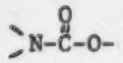
m. monolinuron [3-(p-chlorophenyl)-1-methoxy-1-methylurea]

n. linuron [3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea]

o. metabromuron [3-(p-bromophenyl)-1-methoxy-1-methylurea]

p. buturon [3-(p-chlorophenyl)-1-methyl-1-(methyl-2-propynyl)urea]

3. Carbamates (Urethanes)



a. dichlormate [3,4-dichlorobenzyl methylcarbamate]

b. terbutol [2,6-di-tert.-butyl-p-tolyl methylcarbamate]

c. propham [isopropyl carbanilate]

d. asulam [methyl sulfanilylcarbamate]

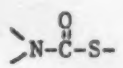
e. swep [methy 3,4-dichlorocarbanilate]

f. chloropropham [isopropyl m-chlorocarbanilate]

g. barban [4-chloro-2-butynyl m-chlorocarbanilate]

h. phenmedipham [methyl m-hydroxycarbanilate m-methylcarbanilate]

4. Thiolcarbamates



a. diallate [S-(2,3-dichloroallyl)diisopropylthiocarbamate]

b. triallate [S-(2,3,3-trichloroallyl)diisopropylthiocarbamate]

c. EPTC [S-ethyl dipropylthiocarbamate]

d. butylate [S-ethyl diisobutylthiocarbamate]

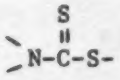
e. pebulate [S-propyl butylethylthiocarbamate]

f. vernolate [S-propyl dipropylthiocarbamate]

g. cycloate [S-ethyl N-ethylthiocyclohexanecarbamate]

h. molinate [S-ethyl hexahydro-1H-azepine-1-carbothioate]

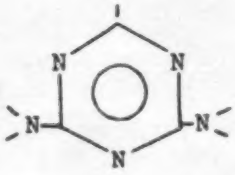
5. Dithiocarbamates



a. metham [sodium methyldithiocarbamate]

b. CDEC [2-chloroallyl diethyldithiocarbamate]

6. Triazines



a. simazine [2-chloro-4,6-bis(ethylamino)-s-triazine]

b. atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine]

c. cyanazine [2-((4-chloro-6-(ethylamino)-s-triazin-2-yl)-amino)-2-methylpropionitrile]

d. trietazine [2-chloro-4-(diethylamino)-6-(ethylamino)-s-triazine]

e. ipazine [2-chloro-4-(diethylamino)-6-(isopropylamino)-s-triazine]

f. propazine [2-chloro-4,6-bis(isopropylamino)-s-triazine]

g. atratone [2-ethylamino)-4-(isopropylamino)-6-methoxy-s-triazine]

h. prometone [2,4-bis(isopropylamino)-6-methoxy-s-triazine]

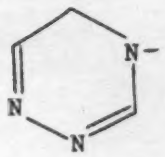
i. desmetryne [2-(isopropylamino)-4-(methylamino)-6-(methylthio)-s-triazine]

j. ametryne [2-ethylamino)-4-(isopropylamino)-6-methylthio)-s-triazine]

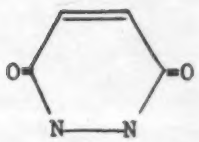
k. terbutryn [2-(tert.-butylamino)-4-(ethylamino)-6-(methylthio)-s-triazine]

l. prometryne [2,4-bis(isopropylamino)-6-(methylthio)-s-triazine]

m. cyprazine [2-chloro-4-cyclopropylamino)-6-isopropylamino)-s-triazine]

7. Asymmetric Triazines 

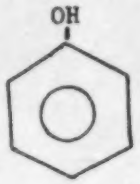
a. metribuzin [4-amino-6-tert.-butyl-3-methylthio-as-triazin-5(4H)one]

8. Azides 

a. MH [1,2-dihydro-3,6-pyridazinedione]

9. Azoles

a. amitrole [3-amino-s-triazole]

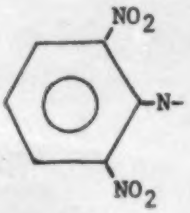
10. Substituted Phenols 

a. PCP [pentachlorophenol]

b. DNOC [4,6-dinitro-o-cresol]

c. dinoseb [2-sec.-butyl-4,6-dinitrophenol]

d. dinosam [2-(1-methylbutyl)-4,6-dinitrophenol]

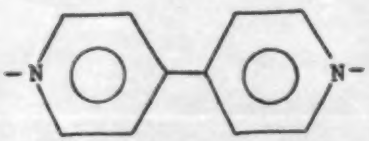
11. Toluidines (Anilines) 

a. benefin [N-butyl-N-ethyl-α,α,α,-trifluoro-2,6-dinitro-p-toluidine]

b. trifluralin [α,α,α-trifluoro-2,6 dinitro-N,N-dipropyl-p-toluidine]

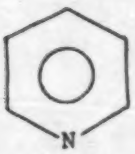
c. nitralin [4-(methylsulfonyl)-2,6-dinitro-N,N-dipropyl-aniline]

d. A-820 [N-sec.-butyl-4-tert-butyl-2,6-dinitroaniline]

12. Dipyridyls 

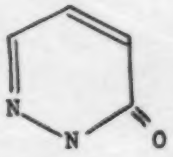
a. paraquat [1,1'-dimethyl-4,4'-bipyridinium ion]

b. diquat [6,7-dihydrodipyrido(1,2-a:2',1'-c)pyrazinediium ion]

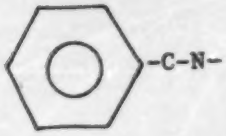
13. Pyridyls 

a. picloram [4-amino-3,5,6-trichloropicolinic acid]

b. pyrichlor [2,3,5-trichloro-4-pyridinol]

14. Pyridazones 

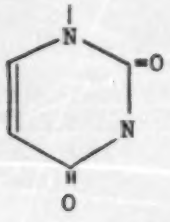
a. pyrazon [5-amino-4-chloro-2-phenyl-3(2H)-pyridazinone]

15. Nitriles 

a. dichlobenil [2,6-dichlorobenzonitrile]

b. ioxynil [4-hydroxy-3,5-diiodobenzonitrile]

c. bromoxynil [3,5-dibromo-4-hydroxybenzonitrile]

16. Uracils 

a. terbacil [3-tert.-butyl-5-chloro-6-methyluracil]

b. isocil [5-bromo-3-isopropyl-6-methyluracil]

c. bromacil [5-bromo-3-sec.-butyl-6-methyluracil]

d. lenacil [3-cyclohexyl-6,7-dihydro-1H-cyclopenta-pyrimidine-2,4(3H,5H)-dione]

Miscellaneous

a. dazomet [tetrahydro-3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione]

b. endothall [7-oxabicyclo(2.2.1)heptane-2,3-dicarboxylic acid]

c. nitrofen [2,4-dichlorophenyl p-nitrophenyl ether]

d. glyphosate [N-(phosphonomethyl)-glycine]

SECTION IX

Herbicide Chemistry Nomenclature

Acid - a substance which tends to lose a proton (form hydrogen ions)

1. acid group - portion of compound which donates hydrogen ion $C(=O)-OH \quad C(=O)-O^- + H^+$
2. aliphatic - open chain compounds.
3. acetic acid - a two carbon acid.
4. saturated - compounds which have no available bonds for sharing.
5. unsaturated - compounds which have available bonds for sharing.
6. double bond = the sharing of two electrons (force joining two atoms).
7. triple bond = the sharing of three electrons (force joining two atoms).
8. functional group = active group or required group.
9. side chain = alkyl (hydrocarbon radicals) groups which replace hydrogen ions on ring compounds.
10. base = compound which tends to gain a proton (form hydroxyl ions).
11. pH = symbol for expressing hydrogen ion concentration; less than 7.0 = acid, more than 7.0 = basic.
12. salt = compounds formed by replacement of hydrogen ions by metallic ions on an acid group.
13. organic - compounds which contain carbon atoms.
14. inorganic - compounds which contain no carbon atoms.
15. halogen - groups consisting of non metallic fluorine, chlorine, bromine, and iodine.
16. ring compound = compounds which share bonds in a manner to form a closed ring.
17. hydrocarbons = general term for organic compounds which contain only carbon and hydrogen.
18. heterocyclic compounds = cyclic or ring compounds which contain carbon and other atoms.

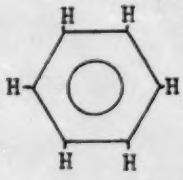
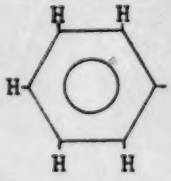
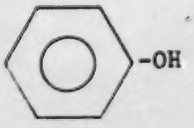
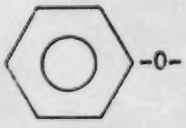
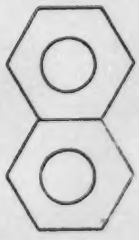
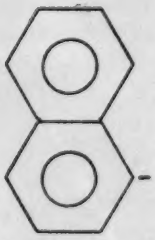
19. aromatic Compounds = six carbon ring structured compounds.

20. bond = force joining two atoms by sharing electrons.

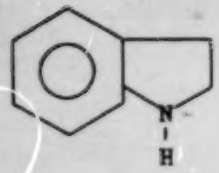
21. hydrocarbon names:

No. of	Saturated		Double Bond		Triple Bond	
Carbons	Compound	Radical	Compound	Radical	Compound	Radical
1	Methane	Methyl				
2	Ethane	Ethyl	Ethene	Ethenyl	Ethyne	Ethynyl
3	Propane	Propyl	Propene	Propenyl	Propyne	Propynyl
4	Butane	Butyl	Butene	Butenyl	Butyne	Butynyl
5	Pentane	Pentyl	Pentene	Pentenyl	Pentyne	Pentynyl
6	Hexane	Hexyl				
7	Heptane	Heptyl				
8	Octane	Octyl				
9	Nonane	Nonyl				
10	Decane	Decyl				
11	Undecane	Undecyl				
20	Eicosane	Eicosyl				
21	Heneicosane	Heneicosyl				
22	Docosane	Docosyl				
30	Triacontane	Triacontyl				
40	Tetracontane	Titracontyl				

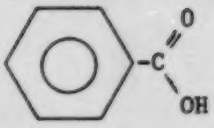
22. Aromatic and Heterocyclic Ring Names:

Name	Structure	The Radical	Radical Name
Benzene			Phenyl
Phenol			Phenoxy
Naphthalene			Naphthyl

Indole

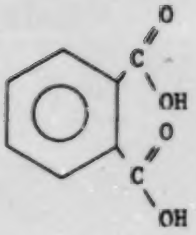


Benzoic Acid



Oxazole

Phthalic Acid

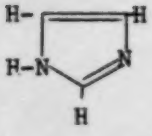


1,2,4 Triazole

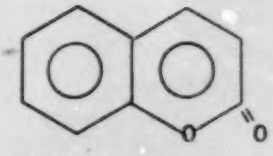
Pyrrole

Pyrrolidine

Imidazole



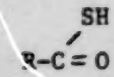
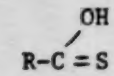
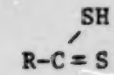
Coumarin



23. Functional Group Names

Group	Formula	As Suffix	As Prefix
Alcohol	R-OH	ol	hydroxy
Ether	R-OR	ether	alkoxy
Aldehyde	R-C-H (O)	al	aldo

Group	Formula	As Suffix	As Prefix
Ketone		one	Keto
Acid		oic-acid	carboxy; carbo
Ester		Ester	carbo-alkoxy
Carbonyl		yl; oyl	carbonyl
Epoxy		epoxide	epoxy
Amine	$R-NH_2$	amine	amino
Amide		amide	amido; carbamyl
Carbamate		urethane	carbamate
Carbamide		carbamide	carbamide; ureido
Hydrazo		hydrazine	hydrazo
Diazo	$-N=N-$	azo; azole	diazo
Oxime	$R-C=N-OH$	oxime	oximino
Guanido		quanine	quanidino
Mercapto	R-SH	thiol	mercapto
Sulfide	R-S-R	sulfide	----

Group	Formula	As Suffix	As Prefix
Thioaldehyde		thial	----
Thiolic Acid		thiolic-acid	----
Thionic Acid		thionic-acid	----
Dithionic Acid		dithionic aicd	----
Thione		thione	----

SECTION X

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